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Green Food Project Geographic Sub Group Report

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This report was prepared by the Geographic Subgroup as a contribution to Defra's Green Food Project. Subgroup membership was as follows: CLA, the Campaign to Protect Rural England, Crop Protection Association, LEAF, the National Trust, the NFU, the National Federation of Young Farmers' Clubs, the RSPB, the Soil Association and the Westcountry Rivers Trust. Documents were also copied to Wildlife and Countryside Link for their comment. The report was drafted by the RSPB as co-chair of the subgroup (with the CLA), based on data and comments provided by the subgroup members. We are grateful to colleagues from Defra, the Environment Agency and Natural England for contributing data and advice throughout this project.

Executive Summary

The Government pledged in the Natural Environment White Paper to “bring together government, industry and environmental partners to reconcile how we will achieve our goals of improving the environment and increasing food production.”

The subgroup aimed to explore from a practical viewpoint how the NEWP objectives might be achieved. We gathered evidence from three geographic areas: North and North West Norfolk, the Tamar river catchment in SW England, and the Lake District National Park. To interpret the goals of production and environmental protection, we followed the framework set out in the National Ecosystem Assessment. We considered provisioning services (food, fresh water), regulating services (carbon storage, water purification), cultural services and biodiversity (which contributes to cultural and regulating services and is valued in its own right). We described tensions and synergies that currently exist between food production and other ecosystem services, explored what changes might be necessary to achieve a better balance of ecosystem services, and suggested how such changes might be achieved.

This process revealed areas of disagreement between subgroup members, in particular:

- Whether there is a need to decrease production in some areas. Many subgroup members interpret the available evidence as showing that we may need to decrease food production in some areas in order to operate within environmental limits. The NFU rejects this view, pointing to actions that farmers can take to reduce the environmental impact of food production without reducing yields, and the potential options offered by future technologies.
- The extent to which land use planning should be centrally led, and to what extent it should be left to the decisions of individual land managers. Many subgroup members agree that some strategic overview of the current and required levels of ecosystem service delivery would enable a more efficient use of land. The NFU does not feel able to sign up to any recommendation that would mean individual farmers had less autonomy over how they manage their land.

Headline results

Optimising the delivery of ecosystem services

- Any growth in production must take place within environmental limits (consistent with the definition of sustainable development used in the National Planning Policy Framework).

- Increasing food production over the short term is possible in some places, but this objective should not override other considerations. In some places, it may be possible to increase both production and other ecosystem services by precision farming, mitigation through agri-environment, application of new technologies etc. In others, production may need to decrease/ radically alter to stay within environmental limits. A key message is 'the right management for the right place' – at all scales from farm to landscape.
- The type of production, (livestock, arable or horticulture, type of cropping etc) as well as the amount is important in both food security and environmental terms. The goal of 'increasing food production' should be considered in the context of what we are ultimately trying to achieve (whether this is for example food security, more efficient food production or a more profitable farming sector) and not merely in terms of tonnage.

Responding to and influencing the drivers of change

- Financial and policy drivers must be aligned with objectives for land management. A combination of price premia for quality products and payment for other ecosystem services (including through the June 2012 CAP and Payment for Ecosystem Services schemes), as well as the necessary infrastructure and skilled labour, is needed to make more environmentally sustainable farming financially sustainable.
- Regulation has a vital role, particularly in protecting high-priority habitats and securing general environmental protection.
- The social/ cultural aspects of farming systems are an integral part of those systems and cannot be ignored when discussing how changes to land management could deliver a better balance of ecosystem services. All stakeholders need to work together to secure economically, environmentally and socially sustainable farming systems for the long term.
- Climate change will be a key driver of change from now to 2050 and beyond.

Improving our understanding

- Further research is needed to better understand how to optimise the delivery of ecosystem services. This includes filling gaps in our knowledge on current productivity and its determinants; current levels of ecosystem service delivery; the interactions between food production, other land uses, and delivery of a range of ecosystem services; and the role of farming in local economies.

- In the longer term, R&D and adoption of new technologies and innovations will play a role in seeking to simultaneously increase agricultural productivity and reduce environmental impacts.

Recommendations

1. Provide land managers and policy makers with sufficient information at the landscape scale to enable them to make strategic decisions on land use.

    a. Defra should provide an online platform to collate spatial information about ecosystem services, currently held by a range of different organisations.

    b. Collaborative, location-based approaches should be further developed and rolled out.

2. Make it easier and more profitable for land managers to undertake land management that delivers the optimum balance of ecosystem services.

    a. Agri-environment schemes (AES) must be underpinned by mechanisms to ensure a basic level of ecosystem service provision and biodiversity protection across the whole landscape.

    b. AES need to be more efficient and effective in order to meet environmental objectives.

    c. Government should support and encourage the development of Payment for Ecosystem Services schemes where appropriate.

3. Focus R&D on developing technologies and new approaches to support productive and environmentally sustainable farming, which is able to meet the challenges posed by climate change.

4. Translate scientific knowledge into practical advice for farmers.

    a. Knowledge exchange mechanisms must be properly integrated, evidence based and outcome focused, with clear objectives and progress monitoring.

    b. An effective knowledge exchange system should include identifiable networks of experts and research centres, and good demonstration facilities.

    c. Local delivery groups and known and trusted agricultural advisers have a key role to play in providing advice as an effective mechanism to secure behaviour change.

d. Online farm-level decision support tools could be developed and made available to all farmers, perhaps as part of the Farm Advisory Service.

5. Ensure other Government policy areas (notably planning policy) are consistent with the objective set out in the NEWP: “to reconcile how we will achieve our goals of improving the environment and increasing food production”.

Report of the Geographic Sub Group

This document is written and owned by members of the geographic sub group. The content does not necessarily reflect the views of Green Food Project Steering Group members.

Background and context

The UK Government initiated the Green Food Project to fulfil its commitment in the Natural Environment White Paper to "*bring together government, industry and environmental partners to reconcile how we will achieve our goals of improving the environment and increasing food production.*" In making this commitment, government recognises that farmers and land managers play a vital role in achieving society's ambitions for water, wildlife, healthy soil, food production and the management of landscapes. Food security is a long-term challenge; farming needs to be supported in building capacity for sustainable production both in the UK and globally. The food chain has major impacts on climate change, biodiversity and the wider environment, which require management.

Current government policy supports increased food production in England as a response both to future threats to global and domestic food security; and to the opportunities for economic growth represented by increased market demand. Government also recently reconfirmed its support (in the National Planning Policy Framework[1]) of sustainable development as set out in the UK's 2005 Sustainable Development Strategy, which include living within environmental limits and ensuring a strong, healthy and just society. Annex 1 provides a summary of the environmental limits within which agriculture must operate, and the legislation and other commitments that have been put in place to reflect these limits.

In England, as in Europe as a whole, many priority species and habitats are associated with farmed land. For example, 20% of habitats listed in the Habitats Directive are permanent pasture/meadow. Therefore farmland has a vital role to play in protecting and enhancing biodiversity and the ecosystem services upon which agriculture, and wider society depends. Biodiversity both depends upon and underpins functioning ecosystems. Some species, such as pollinators and natural enemies of agricultural pests, directly provide an ecosystem service. The range of organisms present in functioning ecosystems provides resilience and adaptability to change. Biodiversity also contributes to cultural ecosystem services like inspiration and tranquillity. Farmed

[1] http://www.communities.gov.uk/documents/planningandbuilding/pdf/2115939.pdf

[2] UK National Ecosystem Assessment (2011). The UK National Ecosystem Assessment:

landscapes are vital for providing a range of cultural services, including high quality landscapes. These are also important for the economy and particularly for businesses that depend on recreation and tourism.

The Natural Ecosystem Assessment (NEA) [2] articulated very clearly the challenges to be addressed. The NEA states that, as well as the positive benefits Enclosed Farmland provides, *"it also imposes important negative effects on the UK, including greenhouse gas emissions, diffuse water pollution and losses to biodiversity".* The report also says that *"until the 1990s, levels of agricultural production increased greatly, causing an increase in external environmental costs and at the expense of other ecosystem services. The increases in total agricultural productivity slowed during the 1990s, and hence the deterioration in other ecosystem services was reduced."* In other words, to date there has been a negative relationship between food production and other ecosystem services, which will have to be reversed if we are to achieve the aims set out in the NEWP. The challenge is to optimise the value of the ecosystem services we obtain from land.

The aim of the Geographic subgroup was to explore from a practical viewpoint how the NEWP objectives might be achieved, by focusing on defined geographic areas in England. The subgroup has contributed material for discussion in the Steering Group and provided evidence for an overall analysis by the Synthesis Group. The current document is the final report from the subgroup.

Sub-group aims, method and analysis

See Annex 3 for the subgroup's work plan and rationale.

The Green Food Project subgroups were asked to consider what actions might be taken between now and 2050 to address the challenges set out in the NEWP. This timescale allows for significant shifts in farming practices and land use, and the possibility of technological innovations. Climate change will be an increasingly important driver of change over this time period.

The geographic subgroup selected three different case study areas to represent a range of farming landscapes: North Norfolk (dominated by arable farming); the Tamar catchment in SW England (lowland dairy and other livestock with some upland areas); and the Lake District (upland grazing livestock). In addition, we focused at a different

[2] UK National Ecosystem Assessment (2011). The UK National Ecosystem Assessment: Synthesis of the key findings. UNEP-WCMC, Cambridge.

scale for each of the case studies to draw out different issues: farm-level examples in Norfolk, the whole river catchment in the Tamar example, and a landscape-scale approach for the Lake District. We gathered data, evidence and views from stakeholders for each of the three case study areas. This enabled us to build a picture of the current level of ecosystem services delivery in each area, and the interactions between food production and other ecosystem services. We then explored what changes might take place between now and 2050 – from adjustments to current farming practices to significant changes in land use or farming systems.

The sub-group considered food production as one of a number of ecosystem services that can be delivered from the case study areas. The range of possible ecosystem services the subgroup could consider was significant, so we focused our efforts on those that are measurable (or where there are reasonable proxies) or which are the focus of specific legal or international commitments. We also attempted to include ecosystem services that are particularly critical or relevant to the case study areas and the farming systems within them. As such, our focus was on: Provisioning services: Food, fresh water; Regulating services: water purification, carbon storage; Cultural services: landscape. Biodiversity underpins many ecosystem services and is valued in its own right, so was considered in its own category.

We were severely constrained by the time and resources available, and although we have made every effort to include a representative range of views and to consider the most important aspects for each case study, we do not claim that this is a comprehensive review of the evidence. Nor does this report set out a vision or strategy for each of the case study areas. However, the study does serve to highlight some of the key areas of consensus and disagreement, similarities and differences, and illustrates where further research is needed.

Summary results

What are the current tensions and synergies between current food/crop production and delivery of environmental protection and enhancement objectives?

The major tensions in all three case studies were around water and biodiversity. Agriculture is in competition with other sectors for water, a particularly significant issue in the East of England region. Water is fundamental for food production as for many other land functions, and is likely to become an increasingly limiting factor as the climate changes. Agricultural activities also impact negatively overall on water quality in all the study areas (while recognising that in some places farmers have been able to alter

farming practices to lessen their impact on local water quality). The Water White Paper quotes figures showing that 'agriculture and rural land management' is the second most common cause of water bodies failing Water Framework

Directive standards, after the water industry[3]. Agriculture contributes around 25% of Phosphate in English waters and between 25 – 50% of the pathogen loadings which affect England's bathing waters. Up to 75% of sediment input into rivers can be attributed to agriculture[4].

Intensification of agriculture has been a factor in biodiversity declines in all three areas; although there are also synergies between food production and biodiversity, since much of England's wildlife depends on certain farming systems. Another synergy is with cultural services: agriculture has helped shaped the landscape and manages many of the features that contribute to the character and distinctiveness of all three areas, contributing to tourism and providing opportunities for recreation. Such cultural effects are hard to quantify in economic terms and are a major focus of the current NEA 'follow-on phase'[5].

What are the ecosystem services of particular local or national importance?

Food production is clearly considered important in all three areas, although its contribution to the total value of ecosystem services provided is probably not equally significant in all places. All three areas contain important habitats and populations of species. The Lake District and the uplands of the Tamar provide important water regulation and carbon storage services. Cultural services are important in all three areas, with a very high significance placed on the historic and societal aspects of farming in the Lake District, and enjoyment of wildlife on the North Norfolk coast, in particular.

[3] The Water White Paper is available online here: http://www.officialdocuments.gov.uk/document/cm82/8230/8230.pdf See the table on page 30 for the summary of 'reasons for failure' of Enlgish water bodies. The water industry is responsible for 2839 failures and 'agriculture and rural land management' for 2753.

[4] Source: Catchment Sensitive Farming website http://www.defra.gov.uk/food-farm/land-manage/nitrateswatercourses/csf/

[5] http://uknea.unep-wcmc.org/NEWFollowonPhase/tabid/123/Default.aspx

How could the existing impacts of food production on delivery of environmental protection and enhancement be addressed and what impact this might have on food/crop production?

A common theme was the need for financial drivers to be aligned with objectives for land management. A combination of price premia for quality products and payment for other ecosystem services (including through agri-environment schemes and grants such as those provided through Catchment Sensitive Farming) is needed to make sustainable farming profitable, as well as the necessary infrastructure and skilled labour. Regulation has a vital role, particularly in protecting high-priority habitats and securing general environmental protection through requiring good farming practice (for example through cross compliance). Regulation should enforce the Polluter Pays Principle, which says that society should not pick up the costs of harm caused by private actions. Good knowledge exchange and advice is also important, including via voluntary initiatives like the Campaign for the Farmed Environment. Looking to the longer term, research, development and adoption of new technologies and innovations will play a role in seeking to simultaneously increase agricultural productivity and reduce environmental impacts.

The strongest emerging theme was the idea of the right management for the right place. This applies from farm scale - siting different crops where they will do best and environmental measures where they will have most benefit - to the landscape or national scale. For example, extensive grazing in the uplands positively affects a range of ecosystem services and so this is an efficient use of land, even though food production levels may be low. In the Lake District in particular, it was apparent that reaching stakeholder consensus on priorities is a vital first step.

If food production were to increase in the case study areas (assuming continuation of current products/crops), what would be the likely impacts on various aspects of the environment?

It was apparent in all the case studies that the answer to this question would depend very much on how this increase was achieved. We were not able to fully explore possible future scenarios with the time and resources we had. Future technologies and innovation may increase the scope for increasing food production without exacerbating environmental impacts. An overarching message is that it is vital to start from an assessment of what the land is capable of, and what cost in terms of loss of other ecosystem services is acceptable, before we decide on our ambitions for food production.

What would long term reconciliation of ecosystem services (food provisioning, biodiversity, water quality, carbon storage etc) look like in each case study and how does this differ between each case study according to local conditions?

This proved a contentious question and there was strong disagreement within the subgroup. It is not possible to give a quantitative answer to this question with the data that were available, and the subgroup members interpret the evidence differently. Two broad views were expressed:

a) Where current levels of food production are causing ongoing declines in (or preventing the recovery of) other ecosystem services, production will need to decrease, or the type of production will need to change, to bring our activities within environmental limits. For example, lower stocking rates in the Lake District have proved necessary to address biodiversity and water quality issues. In some cases a more radical change, such as from arable farming to extensive grazing, or even ceasing production altogether, might be needed to secure the delivery of other vital ecosystem services.

b) Reconciliation of ecosystem services can be achieved without decreasing food production and without radical changes to existing farming systems. This will involve increased production efficiencies (such as those promoted in the industry Greenhouse Gas Action Plan and the EBLEX 'Change in the Air' roadmap). We need to better understand and better manage the interactions between the impacts of climate change, our use of natural resources, wildlife and food production. Key elements in this are an efficient use of nutrients, feed, water, pesticides, energy or light by the plant or animal; using technology and machinery to increase efficiency and target inputs; and reducing waste from the system. Applied research and knowledge transfer will be critical to achieve all this.

We agree that in some circumstances it may prove possible to improve environmental delivery within current farming systems – for example in arable systems by managing areas for biodiversity, using buffer strips to protect water courses, etc. Even in such situations, however, greater environmental benefits might be gained by more significant changes, for example converting to organic farming. It is therefore necessary to make a decision on what level of food production and other ecosystem services is preferred. This decision is made by land managers at the level of the farm, within the constraints and guidance of regulation, incentive schemes etc. The priority for government should therefore be to create a policy framework that makes it easy for people to 'do the right thing'.

Discussion and Conclusions

The challenge set out in the NEWP is "*to reconcile how we will achieve our goals of improving the environment and increasing food production"*. Here we consider each of these goals in more detail.

Farming has changed continuously throughout human history. The most significant recent trend in England was the widespread intensification of agriculture following the Second World War.

This massively increased productivity but also increased environmental costs and had a negative effect on other ecosystem services. Since the 1990s, strong efforts have been made to address the negative impacts of farming, and there have been significant improvements such as the introduction of agri-environment schemes, increases in nutrient use efficiency and a drop in non-carbon dioxide greenhouse gas emissions from farming[6]. However, farming by its nature alters the environment: it involves diverting resources away from 'natural' ecosystem processes towards producing agricultural outputs. In this report, therefore, the subgroup is not envisaging a future where farming has a zero environmental impact. Rather, the goal should be a more sustainable food and farming system. The Foresight report on the Future of Food and Farming states that: "*The principle of sustainability implies the use of resources at rates that do not exceed the capacity of the earth to replace them. Thus water is consumed in water basins at rates that can be replenished by inflows and rainfall, greenhouse gas emissions are balanced by carbon fixation and storage, soil degradation and biodiversity loss are halted, and pollutants do not accumulate in the environment. [...] Sustainability also extends to financial and human capital; food production and economic growth must create sufficient wealth to maintain a viable and healthy workforce, and skills must be transmitted to future generations of producers. Sustainability also entails resilience, such that the food system, including its human and organisational components, is robust to transitory shocks and stresses. In the short to medium term non-renewable inputs will continue to be used, but to achieve sustainability the profits from their use should be invested in the development of renewable resources."*

Sustainability comprises environmental, social and economic aspects. The food and farming system must address all of these aspects to meet the NEWP challenge.

[6] UNEP-WCMC (2011) The UK National Ecosystem Assessment: Synthesis of the key findings, Cambridge 2011.

The NEWP also challenges us to 'increase food production'. Progress towards this goal could be measured simply in terms of tonnes (or calories) of food grown, or economic growth of the food sector (depending on the underlying intention in setting this goal). We could consider the efficiency with which food is grown, i.e. productivity measured in terms of output per unit input. The economic concept of Total Factor Productivity is commonly used and records total economic input against total economic output. However, this measure excludes benefits (such as biodiversity) and negative externalities (such as pollution) that do not have a financial value, so paints an incomplete picture of agricultural efficiency. The question of what it is we are trying to increase is considered further under point 4 below.

To meet the NEWP challenge we[7] need both an understanding of the interactions between food production and the environment; and the tools to achieve the necessary changes on the ground. The total area of farmland in the UK is more-or-less fixed although subject to reductions for development and other land uses. To achieve all of our objectives (food production, economic prosperity, environmental sustainability etc), we will need to use this finite area of land as efficiently as possible, while taking into account the role it has in delivering a diverse range of existing ecosystem services.

Based on the information examined during the preparation of this report, and on the knowledge and expertise of subgroup members and their colleagues, the subgroup has reached the conclusions set out below.

1. Evidence is lacking to enable us to reach an adequate understanding of how to balance the delivery of a range of ecosystem services. The issues facing farming and the environment require urgent action. We will inevitably have to make decisions with a less than 'perfect' understanding of ecosystem service delivery. Nevertheless, improving our understanding would enable better decisions to be made. Listed below are points that the subgroup considers to be key to producing recommendations about how both productivity and environmental delivery can be increased by 2050. In some cases the subgroup has not been able to incorporate the required information into this report due to time constraints; in others the information simply does not exist or is not readily available (for example it is not provided in a format the group could use, or is not freely available in the public domain). The subgroup also recognises that the case study approach we have taken provides a 'snapshot' of the situation in a certain place and time, whereas farming systems and the environment are both dynamic. Long-term data sets would be needed to examine trends over time.

[7] Please note that unless otherwise specified or obvious from context, the word "we" in the conclusions section refers to society/ humanity in general, not to a specific group of people.

a. *Knowledge is lacking of current and potential productivity in given areas and farming systems.* To draw meaningful conclusions about how much we wish production to increase, and about where and how these increases should take place, it is necessary to first have a clear picture of current levels of productivity and its determinants. This information is not straightforward to obtain: yield data at a farm level may be commercially sensitive (although it would be possible to incorporate data into reports in a way that preserves anonymity), an accurate measure of productivity requires data on inputs as well as outputs, and data on the total production of a given region is not readily available at the required level of detail. To answer the challenge posed by the NEWP, we first need to know (among other things) which soils have the capacity to sustainably support increased production, to inform decisions by individual farmers. We also need to know where land has been degraded by unsustainable management in the past, and how to restore this land to increase its sustainable productive capacity.

b. *We need a better understanding of the location and quality of ecosystem services (and of features like biodiversity and cultural heritage, which are not in themselves ecosystem services but which are inextricably linked with their delivery).* On some topics we are currently lacking comprehensive and up-to-date information at the appropriate spatial scale to let us decide how to use land optimally. Data gaps include information on soil (organic matter content at different soil depths, soil carbon content, soil biodiversity), and the location of certain valued and threatened habitats such as biodiverse grasslands. Data sets will also need to be updated as climate change progresses.

c. *We need to collate and update information about the interactions between food production and other ecosystem services at different scales from farm to landscape.* We have included a case study of RSPB's Hope Farm in Cambridgeshire at Annex 4 as an example of a farm-level data set. On this farm, records have been kept of agricultural yields (per hectare and total) and of biodiversity levels during management changes spanning 12 years. Other equally valuable examples exist, for example the Game & Wildlife Conservation Trust's Allerton Project[8] and Unilever's Colworth Estate[9]. There is a need to identify and collate the results of such long-term studies and make this information available to land managers. New

[8] http://www.gwct.org.uk/research__surveys/the_allerton_project/default.asp

[9]http://www.unilever.co.uk/sustainability/casestudies/environment/ukencouragingbiodiversityatcolworthestate.aspx

practices and technology may alter these interactions, so such information needs to be kept up-to-date.

d. *We need to take a holistic view of land use.* Although this project focused on the tensions between food production and environment, this is only a small part of the story. The real question is how we can build a more sustainable food system, which requires a full consideration of food production's place in the landscape and a full life-cycle analysis of the consequences of food production on ecosystem services beyond, as well as within, the farm gates. As well as tensions between food production and environment, there are tensions with other land uses including built infrastructure, water treatment, carbon sequestration, flood protection, biofuel production etc. These tensions can operate at different scales. A farmer generally makes decisions based on his/her objectives for the farm (whether these be profit, maximising yields, environmental performance etc), taking into account agrienvironment payments, agronomist advice etc. However, what is best for an individual farm may not be best for wider society – for example land in the upper reaches of a river catchment might have the potential to store flood water and slow down runoff, preventing soil erosion. It could be farmed intensively (maximising agricultural yield and farm profitability), but may not be able to store flood water as effectively as it would if it was used for extensive livestock grazing (which may decrease profitability but maximise external benefits including flood protection and carbon storage). It may not be straightforward to determine which of these is the 'optimum' land use for that farm. Ultimately we need to make decisions on what it is reasonable for society to expect from land managers, and what combination of mechanisms (including incentive payments and targeted advice and information) will deliver the best results for everyone.

e. *Information is not readily available on the economic activities associated with food production in specific regions.* Farming supports and is itself dependent on a range of industries and activities including abattoirs, food processing and retail, transport infrastructure and consultancy services like veterinary advice, agronomy and specialist graziers. In order to assess the economic and social sustainability of farming, and to determine the barriers to increasing production and improving environmental performance, we need to understand farming's place in local economies.

f. *A standard method is needed for assessing the values of ecosystem service provision, which takes into account society's needs and not only economic value*. Ecosystem services range from 'life support' to services that enhance our quality of life. Some (like food production) are much easier to market and assign values to than others (such as benefits to mental health and social cohesion). However, to

make reasoned decisions about land use it is necessary to consider the full range of ecosystem services, not just the ones with current economic value, as articulated in the NEA. An additional complexity is that how an ecosystem service is valued partially depends on where and who the people are who receive the benefits. Some studies have developed methods for quantifying and valuing ecosystem services and for determining how the overall provision of services would change if an area of land were to be subject to change. The subgroup notes that the follow-up to the National Ecosystem Assessment will further explore economic valuation methods for ecosystem services. Work in developing methods and models will need to be undertaken to take account of likely increases in food prices expected over the next 50 years to allow a cost-benefit analysis of different options. It was not possible in the time available for the subgroup to carry out an analysis of existing approaches to valuing ecosystem services.

2. One size does not fit all. The evidence we have is sufficient to demonstrate that the specific tensions and synergies between food production and other ecosystem services are highly location and context-specific – depending, among other things, on soil type, climate, current and historical land management practices that influence landscape character, social values, other economic activities such as tourism, surrounding land use and the location of potential beneficiaries of the services. Agriculture will almost certainly continue to be of importance in the case study areas we looked at, but tensions and synergies will change over time as farmers adapt their practices to address environmental and other challenges. We believe that some farms have the potential to sustainably increase productivity (including through approaches such as precision farming, and potentially in future through new innovations). Evidence indicates that despite improvements in the last 20 years, some current farming practices are still leading to negative environmental impacts (see for example the National Ecosystem Assessment and the European Nitrogen Assessment). It is of limited use to make generalisations about the impacts of increasing food production on the environment. We need to understand what ecosystem services are being delivered where, and what is the potential to increase their delivery (see also Annex 2 on the concepts of land sparing and sustainable intensification).

3. Increasing food production over the short term is possible in some places, but this objective should not override other considerations. While the National Ecosystem Assessment described the conflicts that may occur between food production and other ecosystem services, our case studies have highlighted the high degree of variability that exists between different geographic areas and at different scales. Although it is not possible in the timescale of this project to make quantitative predictions (and accepting that we cannot predict the impacts of future technology and

innovations), an increase in production in some farming systems would be likely to exacerbate negative impacts on biodiversity and ecosystem services. The aim of land management should be to find the level and type of production that secures the optimum balance of ecosystem services and is sustainable over the long term (see definition at the start of the Conclusions section). Reconciling how we achieve our goals of improving the environment and increasing food production is not the same as maximising production in all areas. Some studies (such as Hope Farm – Annex 4) illustrate situations where it has been possible to maintain or increase production while addressing at least some aspects of sustainability (in this case biodiversity). Other examples may well exist within the case study areas. The Hope Farm study also demonstrates the trade-offs and how they may be minimised. It has been necessary to take some land out of production to achieve the biodiversity gains seen on the farm, but by selecting the least productive land to do this, the overall output of the farm has been maintained.

4. The type of production, (livestock, arable or horticulture, type of cropping etc) as well as the volume of output is important in both food security and environmental terms. Measuring food production is not as simple as recording tonnes of output produced. One thing to consider is the contribution of the crop to human nutrition. At the scale of a farm, if the aim was to maximise tonnage a farmer might choose to grow a high-yield feed wheat rather than milling wheat. However, this might mean the farm used more non-renewable inputs while producing fewer calories for human consumption, because of the less than 100% efficiency of converting grain to meat. Different farming systems are suited to different conditions, and their environmental impacts will vary. For example parts of England (e.g. much of the uplands) are not currently suited to arable production, whereas extensive livestock production in these areas (though it produces a low tonnage of food per hectare) may provide a range of environmental benefits in addition to food. It may be possible for English farming to produce more food/ more diverse food for human consumption by changing what is produced in some places – this is an open question which the subgroup's data do not allow us to answer. Better integration between farming systems (for example mixed farms incorporating both livestock and arable cropping) could in some cases lead to a more efficient use of resources. Economic sustainability of a farm, or of English farming as a whole, similarly does not depend on volume of production alone. The goal of 'increasing food production' should be considered in the context of what we are ultimately trying to achieve (whether this is for example food security, more efficient food production or a more profitable farming sector) and not merely in terms of tonnage.

5. Future innovations such as new crop varieties or management techniques could potentially reduce the conflicts between food production and the environment. In the time available the Geographic subgroup has not been able to consider the potential of such innovations or the timescales needed to develop, test and introduce them more widely. We consider them to be an important part of the mix, but since other subgroups have looked at this issue in depth we have focused instead on the interactions between current systems of production and environmental delivery in specific places. The subgroup noted examples in our case studies, particularly in Norfolk, where farmers are using the latest technologies and innovations.

6. An appropriate mix and intensity of tools/ levers can secure change in farming systems. This mix includes regulation, agri-environment schemes, voluntary initiatives and advice and effective dissemination of new knowledge and technology, as well as market drivers such as food prices. The way stocking rates have changed over time in the Lake District, as agri-environment schemes and other CAP payments have changed and the market has fluctuated, illustrate how farming can be influenced by a range of drivers.

7. Climate change will be a key driver of change from now to 2050 and beyond. The agricultural sector needs (and is required by Government policy) to play its part in reducing net greenhouse gas emissions, which will necessitate changes in farming practices. Furthermore, agriculture is profoundly influenced by weather and longer-term climate patterns. The broad projected impacts of climate change in England to 2050 are milder, wetter winters; hotter, drier summers; growing season lengthened by as much as 120 days per year; as well as secondary effects including shifts in the ranges and activity of species which might be detrimental (pests and diseases) or beneficial (for example natural predators, pollinators) to farming, and impacts on soils such as increased erosion risk (see also Annex 5). There will be regional variations in the change in weather patterns and thus in the changes to farming needed. Farmers will respond to these climatic changes in order to maintain their yields and profits, reduce business risks and take advantage of new opportunities. This response will include small changes to current farming practices (e.g. altering sowing dates) through to growing entirely different crops or shifting farming system (for example from pastoral to arable).

Recommendations

The subgroup has agreed on the following key recommendations for the Green Food Project to take forward.

1. Provide land managers and policy makers with sufficient information at the landscape scale to enable them to make strategic decisions on land use. Decision-makers should consider the options for a given piece of land in the context of ecosystem service provision in the broader landscape.

- Defra should provide an online platform to collate spatial information about ecosystem services, currently held by a range of different organisations. This could include mapping of farming type and productivity, water quality and quantity, soil type and condition, landscape character, local priorities for biodiversity conservation etc. Data on how agriculture contributes to the local economy should also be included where appropriate. This would form a decision support tool which could inform farm level decisions by farmers and advisors as well as guiding policy decisions by Government.
- Collaborative, location-based approaches should be further developed and rolled out. Examples of existing location-based approaches include the Nature Improvement Areas initiative and the Environment Agency's catchment based approach. Such approaches can bring together stakeholders in a specific geographic area to discuss the challenges specific to that area, and develop ways of working together to address those challenges.

2. Make it easier and more profitable for land managers to undertake land management that delivers the optimum balance of ecosystem services. Farmers receive financial returns through the market for producing food, but are not rewarded by the market for providing ecosystem services other than food production. Specific mechanisms are needed to correct this market failure. Land managers should be financially rewarded for providing the services desired by society above and beyond the regulatory baseline.

- Agri-environment schemes must continue to be underpinned by mechanisms to ensure a basic level of ecosystem service provision and biodiversity protection across the whole landscape, whether this is achieved through cross-compliance or a new mechanism like 'greening' of Pillar 1 of CAP payments.
- Agri-environment schemes need to be more efficient and effective in order to meet environmental objectives. For example, to halt declines in biodiversity it is necessary to provide sufficient habitat across the whole landscape, not only in 'hotspots'. Entry Level Stewardship (ELS) is the main mechanism to achieve this, but is not currently meeting its potential. Better advice and information are key in helping farmers make good decisions about option uptake. To ensure all ELS agreements contribute to delivering the objectives of the scheme, changes to

delivery should also be considered, such as structuring around 'option bundles' like the farmland bird package and resource protection package.

- Payment for Ecosystem Services (PES) schemes are a mechanism allowing the provider of an ecosystem service to receive payment directly from the beneficiaries of this service. Government should support and encourage the development of PES schemes where appropriate, including by developing guidelines and principles for PES schemes; and by funding and publishing research into what conditions promote the success of PES schemes. Successful examples of PES schemes include the South West Water Upstream Thinking Project and the SCaMP project[10].

3. Focus R&D on developing technologies and new approaches to support productive and environmentally sustainable farming, which is able to meet the challenges posed by climate change. This can include practices such as Integrated Pest Management and precision farming, and looking at the potential of existing plant species and breeds to address certain challenges as well as developing new varieties/breeds of crops and livestock. R&D effort should be directed to increasing the yields of low-input systems such as organic farming, as well as increasing the efficiency of high-input systems. Research must be carried out to improve our understanding of the interactions between the impacts of climate change, our use of natural resources, wildlife and food production. This includes developing practical solutions to address conflicts between food production and other ecosystem services.

4. Translate scientific knowledge into practical advice for farmers. Farmers should have access to information on how to reduce tensions between food production and environment, as specific to their own farming system and geographic location as possible. Various industry-led initiatives and incentive schemes already exist that aim to fill this need, including Environmental Stewardship, Campaign for the Farmed Environment, Catchment Sensitive Farming and the Voluntary Initiative. Knowledge exchange can also be delivered by other mechanisms/frameworks, e.g. through regulation and advice. Knowledge exchange mechanisms must be properly integrated, evidence based and outcome focused, with clear objectives and progress monitoring. To facilitate better integration of knowledge exchange, there is an opportunity for industry-led initiatives to work together to support common environmental messaging and help co-ordinate delivery at a local level.

[10] See http://www.wrt.org.uk/projects/upstreamthinking/upstreamthinking.html and http://corporate.unitedutilities.com/scamp-index.aspx

- An effective knowledge exchange system should include identifiable networks of experts and research centres, and good demonstration facilities.
- Local delivery groups and known and trusted agricultural advisers have a key role to play in providing advice as an effective mechanism to secure behaviour change.
- Online farm-level decision support tools could be developed and made available to all farmers, perhaps as part of the Farm Advisory Service.

5. Ensure other Government policy areas (notably planning policy) are consistent with the objective set out in the NEWP: "to reconcile how we will achieve our goals of improving the environment and increasing food production". The recently-published National Planning Policy Framework (NPPF) acknowledges both the importance of the rural economy and the need to protect and enhance the environment. The document states that planning must recognise the wider benefits of ecosystem services and should contribute to the Government's commitment to halt the overall decline in biodiversity. The NPPF should be implemented in a way that:

- Ensures that all land use objectives are considered in decision making. The value of land for food production, biodiversity and other ecosystem services should be considered as well as its value for built infrastructure.
- Supports on-farm developments that contribute to the economic, social and environmental sustainability of farming.

Further thoughts from subgroup members

The following points were also considered by the subgroup, but did not meet with full agreement from all subgroup members. However, because there was strong agreement between several subgroup members that these are important points to raise, we include them here as a record of the discussion. They do not form part of the list of recommendations agreed by the group.

- **Eliminating waste.** Possible recommendations include requiring retailers and others in supply chain to remove aesthetic requirements (that do not relate to its safety or nutritional value of food) from their purchasing policies; and full implementation of the Groceries Code of Conduct to foster constructive relationships between suppliers and retailers. Reducing waste on the consumer side (household waste etc) is also necessary. Many subgroup members agree that eliminating waste is a key step in addressing the NEWP challenge, but this issue was not considered by all to be within the remit of the Geographic case study subgroup.

- **Addressing consumption issues.** Again, although the Green Food Project report should acknowledge the importance of addressing both supply and demand issues, specific policy recommendations are outside the scope of the Geographic subgroup report.
- **CAP reform**. The Common Agricultural Policy is clearly one of the most important levers influencing the future of food and farming in England and it was agreed that farmers needed to be better rewarded for the delivery and provision of ecosystem services. However, the detail of CAP implementation is also a contentious area and it did not prove possible to agree specific policy recommendation between all subgroup members. Topics discussed included: how best to ensure that different parts of the Rural Development budget are working efficiently together (e.g. funding for competitiveness measures not driving environmental damage); whether the funding for agri-environment schemes should be increased by transferring money from Pillar 1 direct payments; and how High Nature Value farming could be better supported through the CAP.
- **Regulation.** Some subgroup members suggested recommendations around strengthening the regulatory baseline to ensure a certain level of ecosystem service delivery across the whole landscape. These included: Environmental Impact Assessment regulations should be strengthened and adequately enforced; implementation and enforcement of existing legislation designed to deliver environmental protection should be improved; and the Government should develop a National Strategy on dealing with agricultural diffuse pollution in order to achieve the objectives of the Water Framework Directive. However, this approach was not supported by all subgroup members.
- **Semi-natural grasslands.** It was suggested that Defra should produce a comprehensive inventory of semi-natural grasslands (and associated habitats) as first step towards strengthening protection for these valuable habitats, and ensure this is kept up-to-date; however this was not supported by all subgroup members.

In addition, subgroup members attempted to draft a set of ‘principles for action’, as below. In their current format, these are largely focused on the environmental aspects of sustainability (although the second paragraph on Government intervention also addresses economic and social sustainability). This approach could be possibly developed further into a more complete set of principles that take into account all aspects of farming sustainability.

- Government and stakeholders should agree what constitutes a sustainable farming system, so that all parties are working towards a shared goal. The

following bullet points could be considered as minimum standards for assessing the sustainability of food production in any given area.

- Farmland biodiversity is increasing or is at least stable at sustainable population levels.
- Agriculture is not impacting negatively on sites important for biodiversity.
- Landscape character and historic environment features are not being degraded.
- Farmers are working to reduce their use of non-renewable resources (including through precision farming) and eliminate import of non-sustainable resources.
- Farmers are minimising their use of pesticides through a process of Integrated Pest Management or changes in agricultural systems.
- The agricultural sector is reducing its net emissions of greenhouse gases in line with UK government commitments in a way which does not negatively impact on other environmental aspects.
- No ongoing erosion or degradation of soils is taking place.
- Agricultural practices are not the cause of any water body failing Water Framework Directive objectives.
- Water abstraction by agriculture is not at a level that damages water bodies. These standards should be considered as the 'safe operating area' within which farmers are free to adjust their production in response to market signals.

- The Government's interventions in land management should observe the following principles:
  - **Polluter pays.** Land managers should bear the cost of meeting regulatory requirements wherever reasonable, including the cost of avoiding pollution. This issue affects the whole supply chain e.g. retailers should consider the need for the negative externalities of some systems to be internalised into the cost of production, and this should be reflected in the price paid for products.
  - **Provider gets.** Public money should be used to secure public goods by rewarding farmers for taking action above and beyond the regulatory baseline. Clearly an important policy decision is where to draw this line.
  - **Public payments should only be made in the case of market failure.** Public support should be reserved for non-marketable goods; i.e. farmers should not receive public money for providing goods for which a market exists (food itself being a prime example).

- **Evidence-based.** All policy objectives levers and measures should be based on sound evidence that supports their use against stated objectives.

Further questions and challenges for the Green Food Project to address

The subgroups were asked to explore how the goals of improving the environment and increasing food production might be reconciled. The current document forms our contribution to addressing this question. As the Green Food Project progresses under the guidance of the Synthesis Group, it would be valuable to explore more closely the assumptions underlying the project. We offer here some thoughts from subgroup members[11] to feed into this process.

- **Food security.** England/ the UK has a moral obligation to contribute to global food security, but we need to consider how best we can do this. It is important to recognise that recent reports on global food security (for example the Foresight report and IAASTD's Agriculture at a Crossroads[12]) do not lend any weight to the notion that an increase in food production in the UK will be necessary or even helpful for future food security. The Foresight report states that a global increase in food production is only one of a number of changes that need to take place simultaneously to address global food security, and shows that the greatest benefit from and potential for increased production does not lie within the UK (see Annex 2). England can contribute to global food security by driving forward the development of a more sustainable food system – through leading by example in our own farming systems, and through policies that support the development of sustainable, productive agriculture in developing countries.
- **Economic considerations**. If the policy of increasing food production is based on economic aspirations for the agri-food sector and the wider economy, then we must consider whether increasing the volume of production is the best way to achieve these aspirations. Increasing production may not increase overall profitability of the sector if the effect is to 'flood' the market, and in many areas increased production is likely to result in exacerbated environmental impacts. These will be very likely to affect other sectors, eg water companies and tourism industries, and tax payers but might also impact on the farmer and neighbouring producers, as well as the sector generally, with an overall negative economic impact. An alternative way of achieving economic growth is to increase the value of the product. Our case studies illustrate the importance to individual farm

[11] Please note that this section does not represent the views of the NFU.
[12] http://www.agassessment.org/

businesses of ‘adding value’ to crops by marketing them as a premium product (e.g. regionally distinctive foods, organic produce, “nature-friendly”, high-quality crop varieties for specialist markets), as well as the importance of the income that is available for delivering other ecosystem services (mainly agri-environment payments but with some emerging examples of payment for ecosystem services through other means). One possible model for economic growth of the English farming sector is to focus on high-quality products[13] and on realising the value of other services provided by farming, rather than focusing on increasing the volume of food output. The agri-food sector as a whole contributes 7% to the total UK economy (gross value added). Within this sector, agriculture accounts for only 8%, with food and drink manufacturing the largest contributor at 29%[14]. It therefore appears in any case that increasing the value of the agricultural sector would contribute only a small amount to the UK economy. Agriculture does however have great economic, social and environmental importance within specific regions, and we are in no way arguing against investing in and developing the sector. It is, however, important to be clear on what we are trying to achieve, because this affects the way we go about it.

- **What exactly are we trying to increase?** There are important differences between increasing yield/ productivity per hectare of land, or per unit of other input (e.g. water, nitrogen or calorie), or increasing total production (at the scale of a field, or a region, or the whole country, as well as over different timescales). The way production is measured is also important: we can assess output in different ways, for example in terms of weight/ volume (tonnes of beef or wheat or carrots, or gallons of milk) or calories for human consumption. However, this is only part of the picture: different crops are not interchangeable in terms of their role in human nutrition, and we need to produce the right balance of foodstuffs as well as the right amount. The Green Food Project has talked about increasing food production, without considering which foods we want to increase. Increasing food production will have very different implications (for health, import/export markets, environment, landscape, economy) depending on which crops are increased.
- **Resource efficiency.** Improving resource efficiency, although an important part of improving the environmental impact of farming, is not in itself sufficient to achieve environmental sustainability. Resource efficiency means using less input

[13] A further important point to explore is food pricing. Marketing more sustainably-produced food at premium prices can help to increase farm profitability, but in the interests of social equity high-quality food should be affordable for

[14] Agriculture in the UK 2010, Defra

(such as water, nitrogen or energy) for every unit of food produced. Clearly this is a positive step: greater efficiency means less of the resource is used (all else being equal), and in the case of fertiliser should reduce pollution because there will be less surplus nutrients to escape from the system. However, improving resource efficiency does not necessarily mean that less will be used overall if we are also increasing production. In the case of finite resources like fossil fuels and chemicals derived from them, using them more efficiently may mean that such resources last longer, but does not alter the fact they will ultimately be depleted. Resource efficiency can buy us time but we must use this time to develop sustainable farming methods that do not rely on non-renewable resources. Furthermore, improving resource efficiency does not address all environmental issues, notably biodiversity loss. In the UK, reversing farmland biodiversity declines can only be achieved by implementing land management that provides the resources needed by wildlife within the farmed landscape (whether by introducing areas of habitat into intensively farmed landscapes, such as through agri-environment schemes, or by managing the whole farm in ways that benefit biodiversity, for example extensive grazing or organic farming). Agriculture cannot be truly sustainable without reversing biodiversity declines: biodiversity plays a role in providing many of the ecosystem services on which farming (and wider society) depends, as well as being valued in its own right. Finally, an incomplete understanding of how to measure inputs and outputs can lead to spurious conclusions. For example, extensive livestock farming is considered by some to be inefficient because it uses a large area of land to produce each unit of food, over a longer timescale. Intensive farming of housed livestock fed on concentrated feed is considered to be more efficient. This conclusion is reversed if we consider all the outputs produced by extensive farming (which can include biodiversity, carbon sequestration, water purification, valued landscapes), and if we consider the full life cycle cost and indirect footprint of the inputs required for intensive farming (such as land used to produce the feed).

- **Wider impacts**. The approach we have taken emphasises interactions and impacts within our case study areas. It must be remembered that food production in these regions has implications outside of the study area, for example the import of livestock feed and agricultural inputs, energy and water use, and ‘downstream’ pollution impacts, including on the marine environment. Increasing food production or changing agricultural practices would have implications for these wider impacts as well as the local effects.

Case study reports

Please note that the figures referred to in this section are provided at the end of this document.

Norfolk (National Character Areas 76, 77 and 78)

Current ecosystem service provision

The Norfolk case study area is defined by three National Character Areas: North West Norfolk (NCA 76), Norfolk Coast (NCA 77) and Central North Norfolk (NCA 78) (Figure N1).

In addition to gathering summary data about the region (or the most relevant geographical area where region-specific data were not available), the subgroup considered case studies at the level of individual farms in order to highlight issues that arise at the farm scale. Two case studies are provided in a separate document. *Please note: the content and wording of these case studies reflects the views of the land managers interviewed, which are not necessarily the views of the subgroup.*

Biodiversity

Around 15% of the study area is classified as Biodiversity Action Plan habitat, mostly concentrated in the North Norfolk Coast NCA (Figure N2). Habitats include woodland, reedbeds, and grazing marsh as well as various grassland and coastal habitats and others.

3.7% of the study area is designated as SSSI, again with majority within the North Norfolk Coast NCA (Figure N3). The vast majority of the SSSI area within this NCA is in favourable condition, while in North West Norfolk the majority is unfavourable recovering, and in Central North Norfolk there is an even split between SSSIs in favourable and unfavourable condition.

The coastal zone also has international designations (Special Area of Conservation, Special Protection Area, Ramsar site) and there are several SACs and Ramsar sites across the rest of the study area (Figure N4).

The Natural England HLS targeting statements describe the biodiversity importance of this region. The North Norfolk Coast and The Wash Target Area includes nationally and internationally important areas of grazing marshes, wetland habitats (such as reedbeds and fens), intertidal habitats (such as sand dunes and vegetated shingle) and lowland

meadows. Important heathlands, wood pasture, wet woodlands, ancient semi-natural woodlands and arable species interest are also present. This area supports nationally important assemblages of arable birds and rare arable plants. The Broads and Norfolk River Valleys Target Area is one of the few remaining large areas of lowland river valley grassland in Britain. It is renowned for its remoteness and sheer visual expanse which gives it a unique character. The upper valleys provide a distinct contrast in landscape type. Within this area nationally important areas of biodiversity interest occur including: grazing marshes; wetland habitats (including reedbeds and fens); coastal saltmarsh; coastal sand dunes and lowland meadows. Important areas of heathlands, wood pasture, wet woodlands and ancient semi-natural woodlands are also present. This area is also of national importance for its arable bird interest.

The farmland bird indicator for the entire Eastern region has decreased by 14% since 1994.

Provisioning services: food

Food production is an important aspect of the economy of the study region. As well as income directly from farming, primary production supports and is associated with a network of ancillary businesses involved in food manufacturing, processing and retail. These provide significant further economic benefits but are not considered here due to time constraints.

The majority of the agricultural land is Grade 3, with some Grade 2 and 1 (particularly towards the eastern end of the study area) and patches of Grade 4[15] (Figure N5).

There is a variety of farm sizes in the study area ranging from less than 5 ha (76 farms) to more than 100 ha (321 farms) [16]. Of the 121,000 hectares of farmland, 50,000 hectares are cereals; 25,000 hectares grass and uncropped land; and 20,000 hectares cash roots. The remainder of the land is under oilseeds, other arable crops and vegetables, with small areas for stock feed, fruit and nursery stock. Poultry are by far the most common livestock at over 1.2 million in the study area, with significant numbers of pigs (125,000), sheep (26,000) and cattle (21,000).

In 2010 there were just under 2,500 people employed in agriculture across the three NCAs with just under half being “principal farmers”, 27% “full time workers”, and the remainder “salaried managers”, “part-time workers” or “casual/ gang workers”.

[15] For an explanation of agricultural land classifications see http://archive.defra.gov.uk/foodfarm/landmanage/land-use/index.htm

[16] Source of agricultural data: Defra June Survey 2010 http://www.defra.gov.uk/statistics/foodfarm/landuselivestock/junesurvey/junesurveyresults/

The vast majority of this agricultural activity occurs within the North West Norfolk and Central North Norfolk NCAs – there were only 37 individuals employed in agriculture in the North Norfolk Coast NCA in 2010. This NCA is within an Area of Outstanding Natural Beauty (AONB). Within the AONB the biggest industries are wholesale and retail trade, repair of motor vehicles, then agriculture, forestry & fishing. The mean annual gross household income for 2010/11 in the Norfolk Coast AONB was £30,316 compared to £32,202 in the whole East of England region.

Cultural services: leisure and tourism

Tourism is an important economic activity within the study area. For North Norfolk, tourist expenditure contributes an estimated £358 million to the economy, underpinning 8,000 jobs[17].

An important local service is access to the countryside for recreation and education. This is provided partly via Environmental Stewardship agreements (Figure N6). A significant proportion of the study area comes under Natural England's Higher Level Stewardship (HLS) targeting areas: North Norfolk Coast and the Wash; Broads and Norfolk River Valleys and a fragment of the Breckland area (Figure N7)[18]. This area is recognised as a target area for access provision within HLS, with significant opportunities to provide additional permissive routes that link and extend the existing networks and promote educational access[19]. This area also retains a wealth of very significant archaeological features. Of the sites which are scheduled, many have recently been identified to be at high risk due to intensive arable cultivation so are seen as a high priority for management.

Regulating services: water purification

The ecosystem service of water purification is currently poorly delivered in the case study area. The Anglian region as a whole has the worst water quality of all River Basin Districts in England and Wales. It has the least number of water bodies reaching the required good status and will also have the lowest number of waterbodies achieving good status by 2015. There are a number of impacts causing these failures, with agricultural diffuse pollution known to be important in this region (Figure N8). Anglian Water, the water company who manage this River Basin District, will invest £6.82m

[17] Source: North Norfolk District Council website
[18] Natural England HLS Targeting Statements http://www.naturalengland.org.uk/ourwork/farming/funding/es/hls/targeting/default.aspx?list=true
[19] See http://www.naturalengland.org.uk/ourwork/farming/funding/es/hls/hlsfundingforaccessoptions.aspx for details of which access provision measures are eligible for funding under HLS

between 2010 – 2015 on nitrate removal, UV pesticide treatment and catchment management[20].

In terms of the specific case study area, the Environment Agency 'Reasons for Failure'[21] database shows that 225 waterbodies are impacted by confirmed or suspected diffuse agricultural sources. Of these 18 are categorised as bad; the worst of the categories for water quality under the Water Framework Directive. The majority of the study area is within a Nitrate Vulnerable Zone[22].

Impacts of climate change

Climate change impacts will become increasingly apparent over the period considered by the Green Food Project. In the East of England by 2050 (under a medium emissions scenario), mean temperature in winter is predicted to increase by 2.2ºC and in summer by 2.5ºC. Mean precipitation in winter is predicted to increase by 14% and in summer to decrease by 17%[23]. Equally or more important to farmers will more frequent extreme weather events.

Changes in rainfall and temperatures may impact on the ability to grow certain crops or present opportunities to grow novel ones (see annexe 4). These potential changes must be factored into thinking about increasing productivity. Farmers in the East of England will have to adapt to changes from reduced soil moisture levels and increased soil erosion to a lengthening of the thermal growing season. Farmers will need to deal with new pests and diseases while exploring new heat or drought-resistant crop varieties. During the heat wave of summer 2003 sales of salads and drinks increased noticeably, demonstrating the effect of changing patterns of consumer demand for more 'warmer climate foods'. Refrigeration of foods over long distances will present a challenge under a warmer climate, as will an increased likelihood of food poisoning cases[24]. The availability of water at key times in the growing season is already a limiting factor determining what crops can be grown and how they must be managed in Norfolk. Abstraction restrictions are already being imposed by water companies in response to recent droughts, which is likely to impact on yields and quality of crops requiring irrigation (for example potatoes). The Anglian region is already one of the most water-stressed areas in the country and growth planned for the region will add to the pressure.

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[20] Source: Anglian Water, personal communication
[21] The official database of reasons for failure and is England's official Water Framework Directive data
[22] http://defranvz.adas.co.uk/regional.htm

[23] UK Climate Projections 09 http://ukclimateprojections.defra.gov.uk/

24 Living with climate change in the East of England: Summary Report, UKCIP (2003). http://www.ukcip.org.uk/wordpress/wp-content/PDFs/EoE_summary.pdf

Currently 70 designated nature conservation sites in the region may be at risk from or are being damaged by over-abstraction (NB this is not solely from farming but from a combination of land uses)[25].

The coastal zone of the East of England is vulnerable to rises in sea level, storm surges, and saline intrusion as well as 'coastal squeeze' as coastal habitats are squeezed against hard sea defences. This sub-region is also vulnerable to flooding of coastal habitats and erosion[26].

Modelling of future climate to 2090 predicts little change or a slight decrease in soil vulnerabilty to compaction in North Norfolk[27]. Soil carbon content in the study area is low and stable[28].

Reconciling food production and environment

What are the current tensions and synergies between current food/crop production and delivery of environmental protection and enhancement objectives?

- *Water pollution and demand for water.* Water use leads to clear tensions. Water is a limiting resource in this area, and food production is in competition with other objectives for access to it. Other competing demands for water will inevitably increase given population and house building projections. Agriculture has a negative impact on water quality in this region through diffuse pollution. However, there can also be synergies. Agricultural land is important for intercepting and storing rainfall, and can help to purify water returning to waterways, for example where farmers manage grassland along water courses.
- *Biodiversity.* There is extensive literature[29] documenting the tensions between food production and biodiversity. Within the Norfolk study area as across much

25 Environment Agency (2009) Water resources strategy Regional action plan for Anglian Region. http://publications.environment-agency.gov.uk/PDF/GEHO1209BRKW-E-E.pdf

26 Living with climate change in the East of England: Summary Report, UKCIP (2003). http://www.ukcip.org.uk/wordpress/wp-content/PDFs/EoE_summary.pdf

27 Modelling the impact of climate change on soils using UK Climate Projections - SP0571.

http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=15985&FromSearch=Y&Publisher=1&SearchText=sp057&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description.

28 Bellamy, P.H. et al (2005). Carbon losses from all soils across England and Wales 1978–2003. doi:10.1038/nature04038

[29] See in particular the National Ecosystem Assessment

of England, intensification of farming since the Second World War has led to homogenisation of the landscape, with resulting loss of biodiversity and habitat. However, this study also serves to illustrate synergies between farming and biodiversity, with the area supporting nationally important populations of arable birds and plants. The farm-level case studies show how farmers can contribute to biodiversity objectives through active decisions to provide and manage suitable habitat within the farmed landscape.

- *Climate change.* Agriculture produces emissions of greenhouse gases, but can also lead to sequestration of carbon in soils. The net impact, determining whether farming contributes to or is in conflict with climate change mitigation objectives, depends on specific management practices and on the interaction of land use and natural conditions (particularly soil type: for example arable farming on peat soils can lead to rapid loss of soil carbon). The data we have do not allow us to assess the net impact of farming on greenhouse gas balance in the case study area.
- *Landscape and cultural services.* In the study area, agriculture (both current and historic) is an important part of the landscape character. Farmers are actively providing opportunities for recreation by providing access through agri-environment agreements. Agricultural activities can either damage or help to preserve the historic environment, depending on management practices. The data we have do not allow us to assess the net impact of agriculture on tourism or recreation in the region.

What are the ecosystem services of particular local or national importance?

- *Food production.* This area is a major producer of arable crops, but the importance of food production in this region goes beyond the total volume/ calorific value generated. The area produces regionally distinctive or unique foodstuffs (e.g. malting barley), and in some cases value is kept in the local economy by selling to local markets and processing raw products into higher-value products (e.g. handmade local cheese).
- *Biodiversity.* Biodiversity underpins or contributes to most other ecosystem services as well as being valued in its own right. The study area is home to rare species (including all six arable bird species targeted by HLS, and plants such as night-flowering Catchfly). The pollination services provided by biodiversity (as well as many other services including nutrient cycling) are vital to arable farming in the region.
- *Cultural services.* People are attracted to the area for recreation and enjoyment, as demonstrated by the prominence of the tourism sector. The historic environment is a valued part of the landscape. The assemblages of species

present form part of the area's appeal for tourism and recreation. In a study of the Norfolk coast by the RSPB [30], birds and wildlife were the biggest attraction for visitors, with 34% of respondents identifying them as their main reason for visiting the area. Other important reasons were scenery, landscape, peace and tranquillity. The residents of this area also benefit from these features, in terms of quality of life and also economically[31].

- At the farm scale, management practices can increase soil organic matter, decrease net greenhouse gas emissions and help to protect water quality. Farmers we spoke to felt that these are important ecosystem services that they are providing. However, our evidence suggests that on a national scale these are not carbon-rich soils and water quality is generally reduced by farming in this region. This raises the important question of when land management is considered to be providing an ecosystem service, and when it is simply minimising its own negative impact on potential ecosystem services. For example, a farmer could through applying best practice improve the water quality of water courses on his/her land – but it is possible that water quality could be increased further by ceasing arable farming altogether and e.g. reverting to extensively-managed grassland. Whether this would be desirable would depend on the importance afforded to the marginal decrease in food production versus the marginal increase in water quality.

How could the existing impacts of food production on delivery of environmental protection and enhancement be addressed and what impact this might have on food/crop production?

- Aspects of this problem in lowland faming systems have been extensively researched. There is information on potential win-wins (e.g. benefits of pollinators, other invertebrates and soil structure), some information on the direct benefits of wildlife for agricultural production, especially in relation to beneficial insects, and a growing body of experience on how to manage trade-offs. An effective synthesis of this knowledge is needed.
- We have a good understanding of environmental mitigation within arable farming systems, with a range of fully-developed and tested agri-environment options for arable farms. The RSPB has developed the Farmland Bird Package, which

[30] Valuing Norfolk's Coast http://www.rspb.org.uk/Images/Valuing_norfolks_coast_tcm9-203973.pdf

[31] See for example http://www.rspb.org.uk/Images/naturalfoundations_tcm9-291148.pdf

evidence suggests should reverse the decline of farmland birds within arable and mixed systems[32].

- There is a range of management activities that can be taken at farm level to mitigate negative impacts of food production on the environment. Some of these do not affect (or potentially increase) yield: for example increasing resource efficiency including through precision farming, or building soil resilience (and thus reducing the risk of erosion and run-off) by building organic matter content. Other actions will reduce yield per hectare or overall production; for example taking areas out of production and managing them for wildlife or practicing farming methods such as organic that are beneficial for wildlife but reduce yield per hectare (though not necessarily yield per unit input overall).
- Over the coming decades, new technology and innovation (including new products such as crop varieties and chemicals; new machinery that e.g. reduces soil compaction or energy use; and new practices like different tillage techniques) will play a role in decreasing the environmental impact of food production. The Norfolk case study area includes the sort of large, financially-secure farms that are likely to be 'early adopters' of such innovations. It will be vital to ensure that yield innovations are not promoted that are detrimental to environmental objectives.
- The current structure of the market means that farmers are rewarded for food production (crops have a market value) but usually not for other ecosystem services they can provide. There are already various mechanisms in place that can help to correct this market failure and secure more sustainable land management:
    - Regulation (including cross-compliance and management restrictions on designated sites) should reflect the polluter pays principle and ensure farming practices do not exert unacceptable pressure on ecosystem services – i.e. that they do not cause environmental harm. Regulation needs to be more effective, focused on achieving the required outcome with the minimum bureaucracy, and properly enforced.
    - Knowledge transfer, advice and training play an important role in helping farmers to meet and go beyond best practice. A locally specific example is the Wensum Demonstration Test Catchment project[33], just outside our study area, which is focused on gathering and disseminating information

32 Winspear, R., Grice, P., Peach, W., Phillips, J., Aebischer, N., Thompson, P., Egan, J. & Nowakowski, M. (2010) The development of Farmland Bird Packages for arable farmers in England. Aspects of Applied Biology, 100, 347-352.

33 http://www.wensumalliance.org.uk/index.html

to farmers, the water industry and government agencies to achieve a reduction in diffuse pollution while maintaining agricultural productivity.

- Agri-environment schemes allow farmers to receive an income from land managed for environmental purposes. However, a recent review[34] estimated that the need for environmental land management payments in England was about three times the current budget. An increase on this scale is extremely unlikely, so it is important to look for alternative mechanisms for rewarding environmental land management, including external private funding. There is also a need for improvement in the design of schemes, which is being considered by Defra project 'Making Environmental Stewardship More Effective'.
- Payment for Ecosystem Services schemes are one such alternative mechanism, but our research did not come across any such scheme in the study area.
- We came across several examples of where farmers are marketing their produce as 'local', 'handmade' etc and receiving premium prices. There seems to be potential here for farmers to receive a price premium for environmentally sustainable products. This depends on appropriate measures of sustainability allowing accurate and clear labelling, to enable consumers to make informed choices. Encouraging the public to become more engaged with farming, including through providing access opportunities on farmland, is important to help the public understand what benefits they can gain by paying higher prices for their food. Projects like the NFU-led 'Why Farming Matters to the Broads'[35] are attempting to raise awareness among politicians and the general public.

If food production were to increase in the case study areas (assuming continuation of current products/crops), what would be the likely impacts on various aspects of the environment?

The answer to this question differs depending on <u>how</u> production is increased. The data we have gathered do not allow any quantification of feasible production increases or environmental impacts, but some general conclusions can be drawn.

- One way would be to extend cropping to areas within farms currently managed for environmental objectives. This would reverse the environmental benefits

34Cao, Y. et al (2009) . Estimating the Scale of Future Environmental Land Management Requirements for the UK. http://lupg.org.uk/Default.aspx?page=158

35 http://www.nfuonline.com/News/Why-Farming-Matters-to-the-Broads/

provided by such areas, such as biodiversity and resource protection. Given that farmers generally choose the least productive areas to 'set aside', it seems likely that this approach would not achieve a large increase in overall production for the region. In the longer term, such an approach might actually reduce production: for example soil degradation might accelerate and pollinator populations might crash.

- It may be possible to increase production in the existing farmed area by improvements in husbandry – for example adding organic matter to soils, implementing appropriate crop rotations, matching nutrient and water inputs to crop (or livestock) requirements. These changes could broadly be described as improving the efficiency of farming, and in many cases could have a positive (or at least neutral) environmental impact – although in themselves they would not address issues such as biodiversity declines.
- Total production across the region could be increased by increasing inputs on farms that are currently less intensively managed; for example organic farms. In the absence of mitigation, this would almost certainly have negative environmental impacts including declines in biodiversity, increased greenhouse gas emissions and increased pollution risk.
- In future, technological advances (such as higher-yielding crop or livestock varieties) might make production increases possible. The environmental impacts would depend on the specific technology. For example, a crop variety that could be grown in areas currently unsuitable for arable farming, or which was highly productive under conditions of high inputs, would probably have a negative impact; whereas a variety that used water or nutrients more efficiently or was resistant to pests/diseases might have a positive impact.

What would long term reconciliation of ecosystem services (food provisioning, biodiversity, water quality, carbon storage etc) look like in this area?

- The suitability of the landscape and the market for high value local produce makes large parts of this region very suitable for food production, and it seems likely that agriculture will continue to be the dominant land use over much of the area for the next 50 years. However, changes are necessary to address negative impacts on other ecosystem services (in particular water quality and biodiversity), and to mitigate and adapt to the impacts of climate change.
- Improving the balance of ecosystem services might involve a decrease in overall production, or an increase in some places with a decrease in others, or changes in the *type* of production (for example more integrated mixed farming). Our data do not allow us to be specific about what this balance would be. A general principle is that food production must take place within environmental limits. We

have suggested some minimum standards for assessing this in the ‘Recommendations’ section (although please note that the NFU does not support this approach).

Tamar River catchment

Current ecosystem service provision

This case study focuses specifically on the Tamar River catchment in the South West of England (Figure T1). The River Tamar forms the boundary between the counties of Devon and Cornwall. The catchment is essentially rural in character, although the urban area of Plymouth dominates the lower Tamar estuary.

The purpose of this case study is to highlight issues that arise at the scale of a river catchment.

Biodiversity

12.7% of the Tamar catchment is classified as Biodiversity Action Plan habitat. There is a significant amount of BAP woodland across the area, and areas of blanket bog and upland heathland on the sections of Dartmoor and Bodmin Moor that fall within the catchment. Various other BAP habitats are also represented (Figure T2). Significant parts of the catchment are designated Areas of Outstanding Natural Beauty, and the Dartmoor National Park falls partially within the catchment (Figure T1).

5.6% of the catchment is SSSI. The SSSIs are concentrated on the moors (where most are 'unfavourable recovering' with some 'favourable') and along the lower reaches of the Tamar (where condition is 'favourable') (Figure T3).

The Dartmoor area and the Tamar estuary are designated Special Areas of Conservation, and lower reaches of the Tamar are designated both as SAC and Special Protection Area (Figure T4). The estuary and its habitats are a major frost-free feeding area for wildfowl and wading birds in winter.

The Culm area contains a high concentration of significant wildlife habitat, relative to the lowland farmed landscape of the South West peninsular as a whole. Pasture is the dominant land use in the Culm area, which includes a mosaic of field patterns. This varied landscape supports a diversity of environmental features, with a unique, internationally important wildlife assemblage. A total of 27,444 ha of land in the Culm is in some form of agri-environment scheme, equivalent to 67.5% of the total area. Environmental Stewardship accounts for 81.5% of total agri-environment agreement area.

Much of the Tamar catchment is targeted by the Higher Level Stewardship scheme (Figure T7). Within the Upper Tamar target area nationally important areas for biodiversity occur including: purple moor-grass and rush pasture (Culm grasslands) and

associated hedgebanks, Important areas of wetlands, lowland heathland and woodlands are also present. The Lower Tamar area is a protected landscape and includes a large part of the Tamar Valley Area of Outstanding Natural Beauty. The landscape is largely defined by the lower tidal mudflats and creeks lined with wetlands and a backdrop of pastoral farmland including hedgebanks and orchards with some pockets of market gardening. Within this target area important areas for biodiversity occur including grazing marsh, coastal habitats, heathland and woodlands. Part of the Dartmoor target area falls within the catchment, with nationally important areas for biodiversity occur including blanket bog, upland heathland, fens (such as valley mires), purple moor grass and rush pasture and lowland meadows. Important areas of ancient semi-natural woodlands and wood pasture with veteran trees are also present.

The farmland bird indicator in the SW of England has decreased by 23% and the woodland bird indicator by 13% since 1994.

Provisioning services: food

The majority of the agricultural land in the catchment is Grade 3 and 4, with Grade 5 on the moors and some Grade 2 in the lower reaches[36] (Figure T5). A significant proportion is designated as Less Favoured Area.

Other than land classification, data on farming at the catchment level are not readily available, so we have used information at the most relevant geographic area.

The Tamar catchment is situated across the boundary of several NCAs: the Culm, Cornish Killas, Dartmoor and South Devon – a very diverse area including both uplands and lowlands. Across all the NCAs, there has been a trend towards fewer small farms and more large while the total farmed area remains roughly constant: i.e. farm consolidation, although overall more than half the farms are still under 50ha. The majority of the land area is grass or uncropped, with some arable farming. Most farms are classified as 'grazing livestock'. Poultry are the most numerous livestock in all the NCAs except Dartmoor, followed by sheep then cattle[37]. Dairy farming is dominant in the lowland areas of the Tamar catchment.

Within the Tamar AONB, most farms are grazing livestock/ dairy, with some 'general cropping' and horticulture holdings. Two-thirds of farms are less than 50ha. More than

36 For an explanation of agricultural land classifications see http://archive.defra.gov.uk/foodfarm/landmanage/land-use/index.htm

37 Source: Defra June Survey http://www.defra.gov.uk/statistics/foodfarm/landuselivestock/junesurvey/junesurveyresults/

half the land area is permanent grassland and a further 16% temporary grass, with 21% crops and bare fallow. There are approximately 16,000 sheep and 16,000 cattle. Farming and market gardening were the economic mainstays of the valley economy in the past but are now less and less viable in a fast changing global economy[38].

In SW England as a whole, dairy farms have the highest farm business income (FBI), followed by cereal farms, mixed farms and lastly LFA and lowland cattle and sheep farms. There has been an increase in FBI since 2003 for all farms. Dairy farms have experienced the greatest increase (115%). Lowland and LFA cattle and sheep farms have experienced lower increases (59% and 51% respectively) followed by mixed farms (15%). For all farms Single Payment Scheme (SPS) income accounts for a significant 53% of FBI, followed by agricultural output (21%), diversification (14%) and agri-environment payments (13%)[39]. These totals mask big variations between farm types.

Within the catchment area, the 'agriculture, forestry and fishing' sector employs only 3% of people. The biggest employer is wholesale and retail trade. Nevertheless, agriculture is important to the area's economy and culture. Primary production supports and is associated with a network of ancillary businesses involved in food manufacturing, processing and retail. These provide significant further economic benefits but are not considered here due to time constraints.

Cultural services: cultural heritage, leisure

The Tamar catchment is popular with tourists and holds parts of both Dartmoor National Park and Bodmin Moor. Recent work by South West Tourism and others has concluded the majority of holiday visits to the South West are motivated by the quality of the natural and built environment and by protected landscapes. Tourism is important to the local economy. The tourism sector of the South West's economy is one of its largest industries, with staying visitors contributing £4,928 million in expenditure to the region's economy in 2003, which is approximately 4% of the total annual regional output. The sector is a major employer in the region with over 85,000 employees[40]. 7% of people in the catchment area are employed in accommodation and food service activities and 3% in arts, entertainment and recreation (compared to 3% in agriculture, forestry and fishing). Around 6 – 14% of jobs are supported by tourism in the districts that the catchment falls across.

38 http://www.tamarvalley.org.uk/care/

39 Defra Farm Business Survey

40 South West Tourism website– Accessed 29.3.06

The Tamar Valley AONB includes significant industrial heritage. The Cornish mining landscape is a World Heritage Site. Agriculture has helped shape the landscape and is an important part of its historical legacy and landscape quality. The AONB is valued by visitors for its tranquillity, and the AONB management plan emphasises the importance of low-key tourism infrastructure in keeping with heritage and landscape[41].

Natural England's HLS targeting statements (Figure T7) give further detail of the historic value of the area. The target areas contain historic buildings, registered and unregistered historic parklands, together with scheduled and undesignated prehistoric to Post-Medieval features – many surviving as earthworks, including barrows, field systems, hillforts, mining and quarry sites and coastal defences.

HLS schemes offer funding to farmers providing access to the Tamar countryside – see Figure T6.

Regulating services: water purification

As already mentioned throughout the catchment there is an important and diverse agricultural and horticultural base, with a lot of managed grassland for livestock. The HLS targeting statements for the Upper and Lower Tamar state that resource protection issues are a priority due to the effects of diffuse pollution on farmland upon the valuable wetland habitats within the several tributaries of the River Tamar.

There are 96 river water bodies in the catchment, with a combined length of just over 800 km, and four lakes. Currently, 32% of surface waters (231 km or 29% of river length, but none of the lakes) achieve good or better ecological status/potential. 55% of waters assessed are at good or high biological status now (Figure T8). The main reasons for less than good status are, in order, impacted fish communities, physical modification, high levels of copper, phosphate and an impacted diatom community. By 2015, 24% of surface waters in this catchment will improve for at least one element of good status.

A small area of the catchment is within a Nitrate Vulnerable Zone[42].

Impacts of climate change

Climate change impacts will become increasingly apparent over the period considered by the Green Food Project. In South West England by 2050 (under a medium

41 http://www.tamarvalley.org.uk/

42 http://defranvz.adas.co.uk/regional.htm

emissions scenario), winter mean temperature is predicted to increase by 2.1ºC and summer mean temperature by 2.7ºC. Winter mean precipitation is predicted to increase by 17% and summer mean precipitation to decrease by 20%[43]. Equally or more important to farmers will be increases in the frequency of extreme weather events. Changes in rainfall and temperatures may impact on the ability to grow certain crops or present opportunities to grow novel ones (see Annex 5). These potential changes must be factored into thinking about future productivity.

Reconciling food production and environment

What are the current tensions and synergies between current food/crop production and delivery of environmental protection and enhancement objectives?

- *Water quality.* Less than a third of surface waters (and no lakes) in the catchment achieve good or better ecological status/potential. Diffuse water pollution from agriculture is a significant pressure adversely affecting the condition of some of England's most valued nature conservation sites[44]. It presents a significant challenge to the achievement of Water Framework Directive and Habitats Directive requirements and the delivery of Government targets for designated sites and wider biodiversity set out in the England Biodiversity Strategy. DWPA also has a wider social and economic impact, affecting the quality of drinking water supply, bathing waters, coastal and inland fisheries, recreation and tourism[45]. The recent review of the evidence base for the Nitrates Directive Consultation by ADAS[46] found that nitrate leaching from grassland varies according to the intensity of the livestock system that uses the land and the nitrogen input. Losses of nitrate from intensive grassland management, associated with intensive dairying, often exceeds 50 mg/l even if farmers follow best practice. Nitrate concentrations in excess of 150 mg/l are not

43 UK Climate Projections 09 http://ukclimateprojections.defra.gov.uk/

44 273 SSSI units in England are in adverse condition due to water pollution from agriculture and run-off – the most common cause of failure after 1) inappropriate scrub control 2) 'other', 3) under grazing and 4) over-grazing. See http://www.sssi.naturalengland.org.uk/Special/sssi/reportAction.cfm?Report=sdrt17&Category=N&Reference=0

45 Natural England response to the Implementation of the Nitrates Directive in England 2013-2016 http://www.naturalengland.org.uk/Images/11-12-055Nitrate_Vulnerable_Zones_%20response%20Final%2015%203%2012_tcm6-31053.pdf

46 http://www.defra.gov.uk/consult/files/20111220nitrates-directive-consult-evid1.pdf

unusual below intensively managed grassland. However, nitrate leaching below permanent pasture that is grazed extensively or lightly fertilised, is often well below 50 mg/l. The ADAS review also found that losses of pollutants from grassland systems are correlated with numbers of livestock. Intensively stocked farms generate greater losses per ha and per animal kept. Therefore, a reduction in stock numbers reduces losses of all pollutants. According to the ADAS report, the greatest benefits of reducing stocking density would be felt if there was a reduction in total stock numbers. Although this review was in relation to Nitrate Vulnerable Zones, its findings are equally applicable to areas such as the majority of the Tamar catchment which are not designated NVZs.

- *Biodiversity.* Large areas of the Tamar catchment are intensively-managed grassland, with a low proportion of semi-natural habitat. This homogenous landscape is not favourable to farmland biodiversity[47]. Between 2000 and 2008, the area of permanent grassland increased by 14% but temporary grass and rough grazing decreased by 7% and 23% respectively. High Nature Value (HNV) farmland in the case study area remains vulnerable to a combination of intensification and abandonment of land. Considerable work has been conducted identifying HNV farmland in the case study area and evaluating the tendencies and needs of HNV farming systems and the effectiveness of current policies in maintaining nature values[48]. Profitability is low for many farms with HNV farmland in the Culm and loss of HNV farmland in the area is continuing to take place, with 50% of Grassland/ Heathland County Wildlife Sites in unfavourable condition[49]. The Culm area contains a high concentration of significant wildlife habitat, relative to lowland farmed landscape of the South west peninsula as a whole. In the UK as a whole, only 2% of the grassland area is biodiverse (Priority Habitat) semi-natural grassland. However, lowland semi-natural grasslands are home to 206 UK BAP species and ecosystem service provision is generally higher than from agriculturally improved land (NEA). High Nature Value farming in the Culm includes Culm grassland (unimproved wet pasture consisting of a mosaic of habitats which are characteristic and unique), together with surrounding and

47 Numerous studies demonstrate the importance of landscape heterogeneity for biodiversity. See for example Doxa, A. et al. (2012) Preventing biotic homogenization of farmland bird communities: The role of High Nature Value farmland. Agriculture, Ecosystems and Environment 148: 83– 88

48 Cumulus (2011) ibid 1

49 Kenderdine (2009) Culm Natural Networks – State of Resource Report. DWT report quoted in Cumuls (2011)

buffering semi-improved pasture[50] and woodland, scrub and wood pasture. Even when species-poor, semi-improved pasture can have value as a buffer to priority habitats.

What are the ecosystem services of particular local or national importance?

- *Food provision.* Throughout the catchment there is an important and diverse agricultural and horticultural base. The soils and climate are favourable to a pastoral agricultural system.
- *Cultural heritage.* The AONB in particular has a significant industrial heritage and is an established recreation destination for both Plymouth residents and tourists from further afield. With trends suggesting that heritage and rural tourism are set to expand, there will almost certainly be a growth in tourism and recreation in the Valley.
- *Biodiversity*. The study area includes significant semi-natural habitat and High Nature Value farming systems.
- *Water provisioning.* The Tamar catchment includes parts of Dartmoor and Bodmin moor, which are important for providing drinking water. The management of these areas is connected to the more intensive farming in the lowlands: livestock that are grazed in summer on Dartmoor and Bodmin are often brought down to the lowlands for winter. However, as discussed, agriculture in the lowlands has a negative effect on water quality.

How could the existing impacts of food production on delivery of environmental protection and enhancement be addressed and what impact this might have on food/crop production?

- As across England, it will be vital for farmers, government, conservation bodies and others to work together to develop more sustainable farming systems. The Catchment Sensitive Farming initiative has increased awareness and understanding of the impact of diffuse water pollution from agriculture amongst rural land managers but lack of acceptance from farmers that agriculture makes a significant contribution to water pollution remains a major challenge. For example, NAO (2010) found that 72% of farmers surveyed considered that agriculture contributed only a little or not at all to diffuse pollution[51].
- In some cases, particularly for the small dairy farms that are common in this area, cost is a barrier preventing farmers from improving their environmental

50 i.e., pasture in an altered state due to past reseeding and/or fertilisation but not to the extreme of grassland that is under intensive management.

51 National Audit Office (2010)Tackling diffuse water pollution in England

performance – for example investing in infrastructure to reduce diffuse pollution. Various potential sources of funding exist, including the Catchment Sensitive Farming scheme, Environmental Stewardship, and locally a SW Water initiative called Upstream Thinking[52]. The NFU commented that that a smoother join-up between Catchment Sensitive Farming and agri-environment schemes is needed. Incentive schemes must be underpinned by effective regulation/ cross compliance conditions, reflecting the Polluter Pays principle.

- Better protection of semi-natural habitats and increased public support for their sympathetic management is urgently needed in order to maintain the ecosystem services they provide. The NEA concludes that many ecosystem services are higher in semi-natural than agriculturally improved grasslands including greater carbon storage, less nitrous oxide production, greater water infiltration rates and storage (aiding flood prevention), more efficient nutrient cycling and less pollution. Protected and restored semi-natural grasslands also have the potential to provide recreation and tourism services and pollinator and pest control services for adjacent farmland. The NEA also concludes that agri-environment schemes are critical to maintaining and enhancing the biodiversity and ecosystem services of semi-natural grassland. Evidence suggests that better implementation and enforcement of Environmental Impact Assessment (EIA) regulations are needed to allow proper protection of grassland which is semi-natural or important for priority species[53], particularly given new threats[54]. More than 50% of the semi-natural grasslands present in the case study area in 1980 had been lost by the early 1990s, principally to agricultural improvements driven by poorly targeted subsidy[55]. Recognizing the true value of a healthy natural environment and the services it provides is central to Government policy as set out in the Natural Environment White Paper.
- Various measures could be taken to improve ecosystem service delivery in intensive grasslands, ranging from easy measures that can be incorporated into existing grassland management (for example allowing areas of grass to go to seed to provide food for birds, or using a greater diversity of grasses and

52 http://www.southwestwater.co.uk/index.cfm?articleid=8329

53 Grassland Trust (2011) Nature's Tapestry http://www.grasslands-trust.org/project.php?projectid=7

54 such as the 2014 date for permanent grassland reference area in the draft CAP regulations

55 Quoted in Defra evidence paper from Cumulus Countryside & Rural Consultants. (2011). High Nature Value farmland in Rural Development policy – Culm Grassland Case Study; Report for European Forum on Nature Conservation and Pastoralism. Report No:CC-P-504.3, Issue 2.0

legumes in temporary grasslands), to more radical changes such as a move to mixed farming, more extensive grazing or horticulture. The Dairy subgroup of the Green Food Project has explored in depth environmental improvements that could be made within the Dairy sector.

- As previously mentioned, the climate and soils of this area are well suited to grass farming and this is likely to continue to dominate. Agri-environment options for grassland farms have lagged behind development of arable measures. However, there has been increased research effort in this area during the last five years (See for example Buckingham et al. 2011, Peach et al. 2007 and Pywell et al. 2007). For species rich grasslands, we have a fairly good grasp of the impact of soil pH, nutrient status, fertilisers and manures on species-rich grassland (Kirkham et al, in prep) and the management needed to restore and re-create most types of species-rich grassland, though this knowledge has served to highlight how difficult this management can often be to achieve in practice.
- In some cases farmers can reconcile food production and the environment within current farming systems, supported by tools such as advice and incentive schemes. However, in some circumstances, a more radical change (such as a change of farming system) may have multiple benefits for both farm profitability and environmental performance[56]. The National Trust's land at Hartland and Middlebere in Purbeck, Dorset is an example. In the past two decades, a combination of economics, legislative changes and opportunity have shifted the farming system from conventional dairy farming and potatoes to extensive cattle farming in tune with habitat management and especially heathland restoration. Hartlands farm was managed as a conventional dairy unit into the 1990's. At that time, it was recognised that a substantial investment in dairy infrastructure would be needed simply to keep up to date with legislative requirements including the Nitrates Directive. It was clear that in this location a different approach to viable land management would be needed – the Hartland moor heathland restoration project was born. Initially, cross-bred Red Devon cattle were introduced onto Hartland Farm as back up grazing for nearby heathland at Middlebere. The return to extensive grazing generated community support and the local NT members association contributed financially to breeding livestock. In recent years management has been further improved under a contract arrangement with a local farmer and the cattle now form a pedigree Red Devon suckler herd

[56] There was some disagreement here between the NFU, who felt that the emphasis should be on the more 'accessible' actions farmers can take to improve environmental performance of current farming systems, and other subgroup members who felt that the need for more radical change could not be ruled out.

producing quality store cattle and in-calf breeding stock. The primary objective remains habitat management but importantly the land is still valuable in production and economic terms.

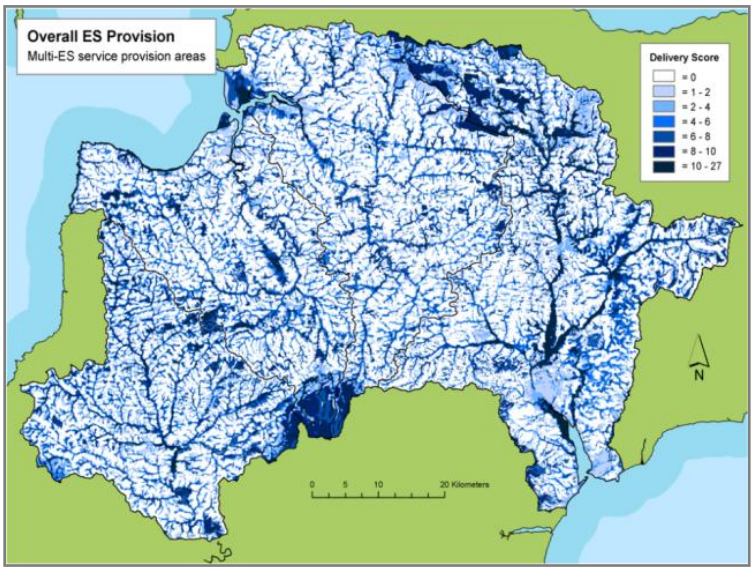
If food production were to increase in the case study areas (assuming continuation of current products/crops), what would be the likely impacts on various aspects of the environment?

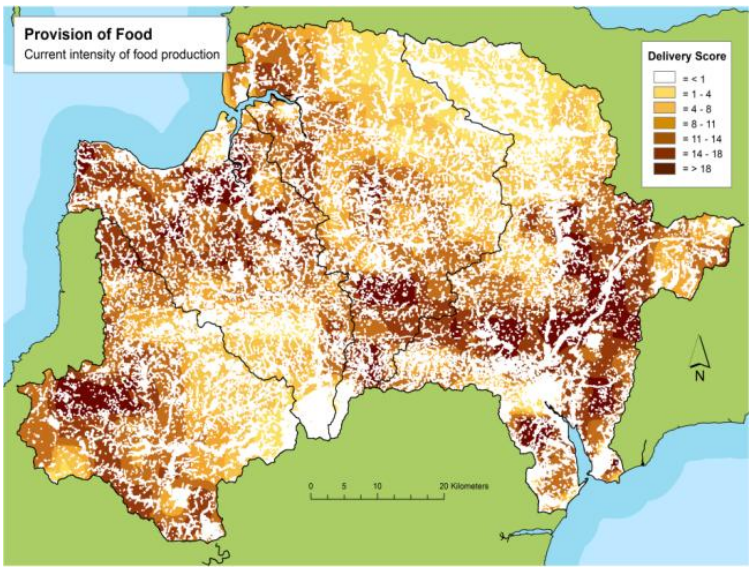
- This is a very difficult question to answer for this area without more specific information. The evidence presented above suggests that increasing livestock production by further intensification of current systems would exacerbate existing negative impacts on water quality and biodiversity, in particular. If a different way was found to increase production then the environmental implications would be different.

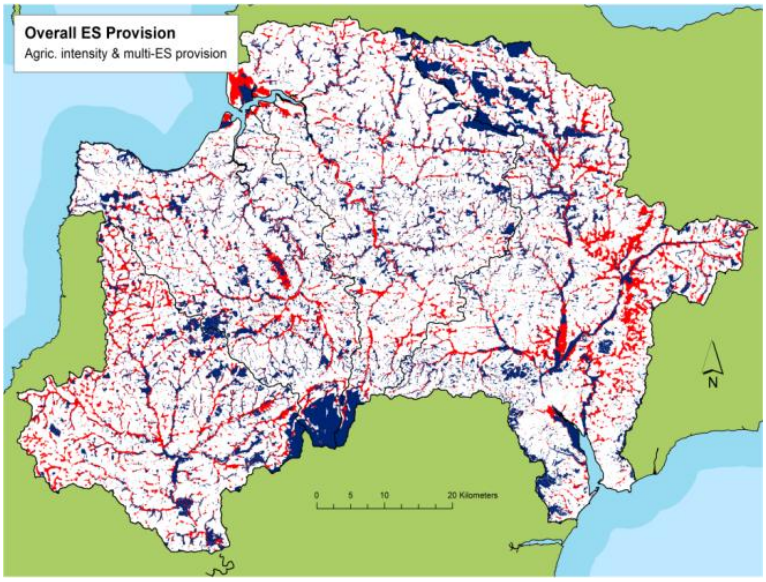
What would long term reconciliation of ecosystem services (food provisioning, biodiversity, water quality, carbon storage etc) look like in this area?

- One approach to answering this question is illustrated below by the work of the Westcountry Rivers Trust (2012; Paling, *N et al*, 2012) The WRT have developed simple rules to map land areas that are likely to play a key role in the provision of the ecosystem services listed below. The models have been developed to be informative at a whole-catchment scale and to facilitate the identification of important multi-functional areas where intensive agricultural production should be avoided to protect the provision of these vital ecosystem services. The models are also intended to be used as an engagement tool that can be used to initiate discussion between stakeholders, to provide evidence to funding organisations and to target and tailor catchment management initiatives. The Rivers Trust's intention is for the Tamar Pilot Project to produce a transferable scalable method for a catchment planning process which can be rolled out across England.
- The following layers summarise the key ecosystem services that the WRT have mapped:
  1. Provisioning Fresh Water – providing potable water
  2. Regulating Water Purification – regulating general water quality
  3. Regulating Water (flooding) – regulating flood
  4. Regulating Water (drought) – regulating drought
  5. Regulating Climate regulation (greenhouse gas sequestration
  6. Cultural Recreation and Tourism – Can people use the area
  7. Supporting Provision of Habitat – protecting, increasing and linking important habitats

- The land area remaining after the spatial mapping of these services is regarded as being most suitable for the intensive, but sustainable production of food. Comparison can then be drawn between the areas predicted to be appropriate for the production of food and a map of the current distribution of agricultural production across the landscape.
- An example of a WRT mapping exercise is included below but generally this is derived in collaboration with a stakeholder group, who decide how to weight the different ecosystem services (i.e. they assign different values). The Tamar is the leftmost catchment on these maps. The first map shows overall ecosystem service provision, the second shows the current intensity of food production, and the third explores how land is used. The blue areas represent areas that are currently not under intensive agriculture; the red areas represent conflict between intensive agriculture and eco services. *Maps are copyright of the Westcountry Rivers Trust and reproduced with their kind permission.*




Provision of Food
Current intensity of food production
Delivery Score
= < 1
= 1 - 4
= 4 - 8
= 8 - 11
= 11 - 14
= 14 - 18
= > 18
N
0 5 10 20 Kilometers


Overall ES Provision
Agric. intensity & multi-ES provision
N
0 5 10 20 Kilometers

Lake District National Park

Current ecosystem service provision

The Lake District National Park was designated in 1951. It is the largest of the English National Parks (and the second largest in the UK). The Park is located in Cumbria and contains both upland and lowland areas (Figure L1).

This case study focused on issues that arise at the landscape scale. Extensive work has been carried out by a variety of authors on ecosystem service provision in the Lake District and UK uplands more generally. This includes Natural England's Bassenthwaite Ecosystem Pilot[57], the Cumbria Fells project on the Environmental, Economic and Social Contribution of Hill Farming[58] and a wealth of others. Due to time constraints, it was not possible to carry out a systematic review and synthesis of this information; rather we have drawn on evidence sources suggested by subgroup members on an 'ad hoc' basis.

Biodiversity

Around 29% of the National Park is classified as Biodiversity Action Plan habitat (Figure L2). Major habitats include upland heathland, blanket bog, woodland, fens, grazing marsh and lowland heathland. Many nationally important species are found here including 173 species in the UK Biodiversity Action Plan, such as red squirrels and natterjack toads.

18% of the National Park is designated as SSSI. Of this area, most is in 'unfavourable recovering' condition, with some in favourable condition and small amounts in 'unfavourable no change' and 'unfavourable declining' (Figure L3). The main outstanding issues on SSSIs are invasive non-native species and grazing.

The National Park contains 8 National Nature Reserves (NNR), 3 RAMSAR Sites (internationally important wetland designation)[59], as well as significant coverage of Special Areas of Conservation and a small amount of Special Protection Area (Figure L4). In all over 36,000 hectares of the National Park are in European designated sites, as well as 14,000 hectares in County Wildlife Sites and 8,000 hectares in Regionally Important Geological Sites. The Park has also been nominated as a World Heritage Site.

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57 http://rebanksconsultingltd.com/resources/Appendix%20-%20Bassenthwaite%20Catchment%20Case%20Study%20_final_.pdf

58 http://www.cumbriahillfarming.org.uk/pdfs/Appendix3.pdf

59 http://www.lakedistrict.gov.uk/

Around three-quarters of land in the National Park is in agri-environment schemes (table 2) and over 17,000 hectares of land have been in Woodland Grant Schemes since 2007[60].

Table 1: Area of land in agri-environment (Source: Natural England, April 2011)

Agri-environment schemes	Area under agreement: Holding clipped to National Park boundary(ha)
Entry Level Stewardship	13,407
Entry Level plus Higher Level Stewardship	37,622
Higher Level Stewardship	760
Organic Entry Level Stewardship	1,288
Organic Entry Level plus Higher Level Stewardship	1,745
CSS	5,099
Lake District Environmentally Sensitive Area	109,520
Total (NB there are some small overlaps in area between different schemes but these are a small percentage of the overall figure)	169,441 74% of the total area of the National Park

The Natural England HLS targeting statements describe the biodiversity importance of this region. The Lower Fells target area includes the southern fringe of the Lake District National Park. Its gentle pastoral landscape provides a contrast with the more dramatic Cumbria High Fells to the north. Throughout this target area nationally important areas of lowland heathland, lowland raised bogs, upland calcareous grassland, juniper scrub and saltmarsh occur. Important areas of upland heathland, upland hay meadows, and

60 State of the Lake District National Park Report March 2012

woodlands are also present. Species include small pearl-bordered and high brown fritillary butterflies, netted carpet moth and internationally important populations of natterjack toads and freshwater pearl mussels. The High Fells target area comprises of the core of the Lake District National Park. Throughout these areas habitats of national biodiversity importance occur including montane heath, upland heathland, blanket bog, upland rock ledge and scree communities, juniper scrub, upland calcareous grassland, upland flushes, fens and swamps, purple moor grass rush and pasture, upland and lowland hay meadows and woodlands. Species include marsh fritillary butterfly, netted carpet moth and dormouse. Upland breeding waders are present.

However, despite the high priority afforded to biodiversity in many parts of the Lake District, some species are still declining – reflecting the extent of the issues that remain to be addressed. A 2007 report[61] documents gives examples of such declines. Between 1995 and 2004, the number of butterfly species recorded declined in 57% of sample plots within the Park. Over the last 20 years, lapwings declined by 63% and curlews by 39%. Formerly widespread species, including the corncrake, yellow wagtail and yellowhammer, have also declined, at varying rates and for a variety of reasons. In Cumbria as a whole, 40% of heathland has been lost since the mid 20th century. Continued effort will be needed to reverse these declines.

Provisioning services: food, fresh water

The majority of the agricultural land is Grade 5 with some Grade 4 and patches of Grade 3[62] (Figure L5), and a significant amount is classified as Less Favoured Area. Holding sizes range from less than 5ha (the most common category) to more than 100ha with the majority of agricultural land (115,000 ha or 90%) being permanent pasture or rough grazing. Sheep are the most common livestock (660,000 animals at the Defra 2010 census), though there are also significant numbers of cattle (68,000) and pigs (3,220). 1,300 ha are arable crops. Information was not available about the total amount of food production from the Lake District National Park.

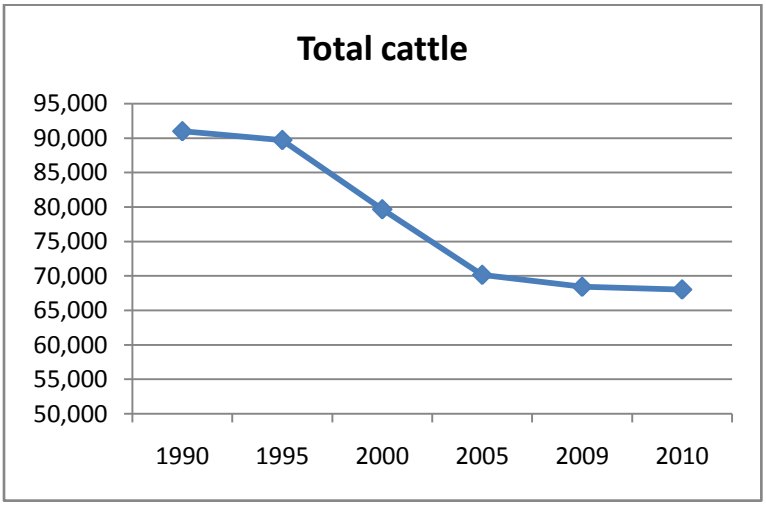
Livestock numbers have declined since 1990 (see graphs below[63]). This is a result of a combination of economic factors, including the end of production subsidies, and the

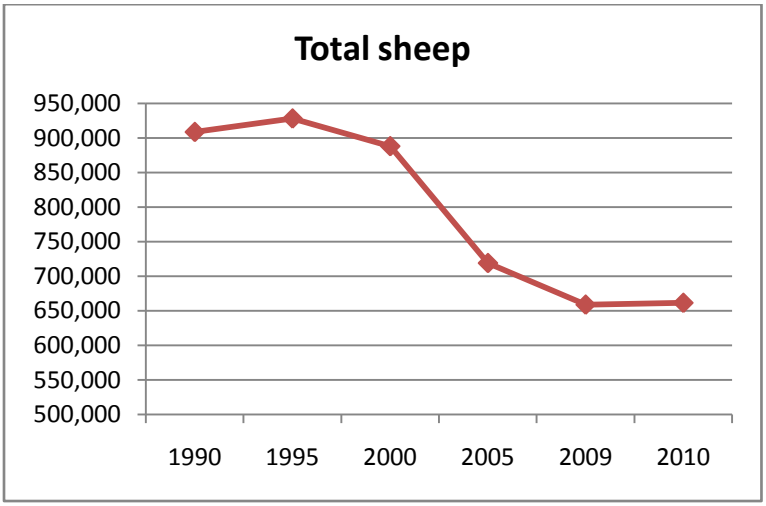
61 RSPB (2007) Uplands: time to change?

62 For an explanation of agricultural land classifications see http://archive.defra.gov.uk/foodfarm/landmanage/land-use/index.htm

63 Defra June census. Results for 2009 onwards are available for commercial holdings (any holding with >5 ha of agricultural land, 1 ha of orchards, 0.5 ha of vegetables or 0.1 ha of protected crops, or >10 cows, 50 pigs, 20 sheep, 20 goats or 1,000 poultry).

influence of agri-environment schemes. *Please note the vertical axes do not start from zero and are different for the two graphs.*





Over 2,500 people are employed in agriculture in the National Park. The 'agriculture, hunting, forestry and fishing' sector accounts for 8% of employment within the National Park (table 2). Farm incomes are low, with a net farm income of £7,704 in 2009 to 2010, down on the previous year's figure of £9,155. This drop reflected the regional and national picture of a reduction in farm income[64].

[64] State of the Lake District National Park Report March 2012

Table 2: Employment in the Lake District National Park

Sector	% employed	Sector	% employed
education/health/social work	15	public admin and defence	11
hotels & restaurants	14	real estate/ renting/ business activities	10
construction	12	manufacturing	9
wholesale/retail/ car repair	11	agriculture, hunting, forestry and fishing	8

The National Trust is the single largest landowner in the Lake District, followed by United Utilities and the Forestry Commission. The Lake District National Park has the largest concentration of common land in Britain, and possibly Western Europe. Common land is a piece of land in private ownership, where other people have certain traditional rights to use it in specified ways, such as being allowed to graze their livestock. Common land is vital to farming in the Lake District: many hill farmers don't have that many in-bye fields and rely on the fells for grazing sheep. This system has survived unchanged in its essentials for generations.

One of the most significant ecosystem services provided by the uplands of the National Park is fresh water. The Thirlmere and Hawswater catchments alone supply a quarter of North West England's water for domestic and industrial use[65]. See also the section on water purification below.

Cultural services: cultural heritage, tourism

The Lake District's farming landscape represents something of significant historical importance. It is an ancient farming tradition that has partly evolved to accommodate modern machinery and practices, but has retained features like the key elements of the

65 Natural England Cumbria High Fells report

farming culture and the systems of land tenure, including stock management and breeding practices.[66]

Most of the National Park falls within Natural England HLS targeting areas – High Fells and Low Fells (Figure L6). The Fells are rich in internationally important historic sites including prehistoric and Roman earthworks, mining and quarrying remains and traditional buildings. Key characteristics are the designed historic landscapes including wood pasture and parkland. Boundaries including stone walls and hedges are prominent features of the landscape and often define historic field patterns, such as open field or strip field systems, or follow historic boundaries such as fell walls. The Lake District Partnership has proposed that the Lake District should be a World Heritage Site, with cultural heritage at the heart of the nomination[67].

Tourism is very important in economic terms. The Park receives 15.8 million visitors a year, and in 2009 visitors spent £925.7 million[68]. The area's cultural heritage, including its farmed landscapes and built environment, is an important part of the visitor experience and a significant generator of income. The majority of people come to the Lake District National Park because of its spectacular scenery and the peace and quiet it offers[69].

The Lake District National Park has the highest concentration of opportunities in England for active pursuits, including walking, fell running, orienteering, rock climbing, horse riding, mountain biking, canoeing, fishing and inland boating. Following the Countryside Rights of Way Act 2000 and building on a long tradition of open access to the fells, 55% of the National Park is accessible on foot by right[70] (see Figure L7).

Regulating services: water purification, climate regulation

In 2010, 29% of lakes and 42% of rivers in the Lake District National Park were in at least 'good' ecological status (see also Figure L8). This is not a significant improvement since 2009, when figures were 29% for lakes and 38% for rivers. Under the Water Framework Directive the aim is for all water bodies to reach good ecological status by

66http://www.rebanksconsultingltd.com/resources/Farming%20Contribution%20to%20WHS%20Cas.pdf

67 http://www.lakeswhs.co.uk/

68 www.lakedistrict.gov.uk/

69 State of the Lake District National Park report http://www.lakedistrict.gov.uk/caringfor/state_of_the_park

70 Ibid.

2015: under current trajectories this aim will not be met. According to the Lake District Partnership's plan, overall water quality in the Lake District has been declining due to diffuse agricultural pollution, erosion and detergent use. This affects bathing and safety and is a symptom of failing ecosystems. The drought conditions of 2010 highlighted the impact of excessive drawdown of lakes used for water supply. There were profound effects on biodiversity, views and recreation[71].

The Catchment Sensitive Farming initiative aims to enable farmers and land managers to take voluntary action to reduce diffuse water pollution from agriculture through providing advice and capital grants. The 2012/13 funding priorities for the Bassenthwaite catchment are to reduce dirty water runoff from manure stores, silage, animal handling areas and yards; increase slurry and midden storage capacity by roofing stores; move and upgrade sheep dip/pen facilities; restore poached gateways and farm tracks; and remove stock from watercourses to stabilise banks.

Carbon storage is another significant ecosystem service provided. Peat and carbon soils are significant in the Cumbria High Fells where there is extensive blanket bog[72]. These areas are a nationally significant store of organic carbon. Many of the NW uplands deep blanket bog contains up to 1,000 tonnes of carbon per ha. Monitoring of the condition of blanket bogs on SSSIs suggests that a high proportion of these bogs are in poor condition due to past drainage. As a result, many of the blanket bogs are currently net sources of greenhouse gas emissions, including carbon dioxide, methane and nitrous oxide[73].

Impacts of climate change

Climate change impacts will become increasingly apparent over the period considered by the Green Food Project. In North West England by 2050 (under a medium emissions scenario), winter mean temperature is predicted to increase by 1.9ºC and summer mean temperature by 2.6ºC. Winter mean precipitation is predicted to increase by 13% and summer mean precipitation to decrease by 18%[74]. Equally or more important to farmers will be increases in the frequency of extreme weather events. See Annex 5 for further impacts.

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71 Lake District Management Plan http://www.lakedistrict.gov.uk/aboutus/partnership/ldnppmanagementplan

72 Natural England Cumbria High Fells report

73 Source: Natural England briefing paper

74 UK Climate Projections 09 http://ukclimateprojections.defra.gov.uk/

Modelling of future climate to 2090 indicated that some soils in the Lake District are vulnerable to compaction, but there is likely to be little change in this factor as a result of climate change[75]. Soil carbon content in the study area is variable with some areas facing rapid loss[76].

The Natural England Cumbria High Fells report listed a variety of possible impacts of climate change.

- The structure, species composition and dynamics of some habitats may alter. Some species may only survive if they can colonise and survive in different places. Upland areas will become refuges for species moving into them from lower levels. It is likely that a number of arctic-alpine species will be lost as they face increasing competition from other species moving into the same ecological niche.
- Increases in the number of non-native and invasive species.
- Increase in the risk of peat and bracken fires.
- An increase in winter rainfall may increase erosion, resulting in more nutrients and sediment being washed into lakes and rivers. This will interact with run-off from agriculture and localised erosion caused by walkers and cyclists on the fells. The impacts from this include both soil loss and decline in water quality.
- A decrease in summer rainfall may lead to a decrease in lake water levels. This will impact on water resources. Summer drought could lead to a decrease in the water that is available for recreation. A decline in water quality (due to reduced dilution of pollutants) and an increase in algal blooms may also affect the recreational potential of the lakes during summer.
- Peat soils will be more easily lost through erosion due to drying out. Drying out of peat soils and blanket bog would release significant amounts of carbon dioxide to the atmosphere, exacerbating climate change. Drying out of peat soils may lead to the disturbance of buried archaeology.
- Where semi-natural woodland is of a similar age structure, storm events may open up areas where young tree regeneration can take place. Ancient trees in parkland and wood pasture will be more susceptible to wind damage.

Possible indirect impacts include:

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75 Modelling the impact of climate change on soils using UK Climate Projections - SP0571.

http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=15985&FromSearch=Y&Publisher=1&SearchText=sp057&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description.

76 Bellamy, P.H. et al (2005). Carbon losses from all soils across England and Wales 1978–2003. doi:10.1038/nature04038

- An increase in the intensity of grassland management and, potentially, in the area of cultivation in the valley bottoms as a response to longer growing seasons. Coupled with demands for more or new crops, this may exacerbate pressures on land use and semi-natural habitats in the valley bottoms and lowland fringes.
- The timing of grazing and cutting and stocking levels will have to change in response to seasonal changes in grass production.
- A longer growing season may favour more commercial tree species and could provide more wood for coppicing, charcoal production and fuel. This has the potential to have a positive or negative impact on the landscape depending on what species are planted where.
- Renewable energy infrastructure could lead to conflicts with landscape, biodiversity and tourism interests and will be another pressure on land use within the area.
- Increasing pressure for food production on land use in valleys, in response to concerns about food security and population growth, may reduce the extent of floodplains, increasing flood-risks downstream.

Reconciling food production and environment

What are the current tensions and synergies between current food/crop production and delivery of environmental protection and enhancement objectives?

- Both tensions and synergies revolve around stocking levels. A certain level of grazing, with an appropriate mix of cattle and sheep, maintains the habitats that underpin many of the ecosystem services provided by this area. With over- or under-grazing, or an over-emphasis on sheep, these ecosystem services decline.
- The special farming system in this area and the culture associated with it (including common land, certain uses of in-bye e.g. for producing winter forage, and specific land management skills) are an essential aspect of ecosystem service delivery in the Lake District. Tensions can result when attempts to improve ecosystem service delivery fail to recognise this fact. There is a growing awareness of the need to work together (farmers, conservationist and others) to secure more economically viable and environmentally sustainable grazing regimes.
- The strong cultural values associated with farming in the Lake District can itself lead to tensions. A report by the Macaulay Institute and University of Central Lancashire on “Social Capital in Hill Farming” demonstrated the mismatch in how different groups value the services provided by farming. The table below shows a comparison of farmers’ perception of the benefits of upland farming with that of the public in rural areas (Cumbria) and urban areas (Manchester). Participants were asked to rank the 8 benefits in order of importance, with 1 being the most important:

	Cumbria farmers	Cumbria public	Manchester public
1. Traditional farming skills	1	5	6
2. Small family farms	2	4	8
3. Strong local culture	3	2	5
4. Traditional buildings and stone walls	4	6	7
5. Wildlife	5	1	1
6. Community culture	6	3	3
7. Scenic views	7	8	4
8. Peace and tranquillity	8	7	2

What are the ecosystem services of particular local or national importance?

- *Water provision and purification.* Catchments in the Lake District supply a significant proportion of the region's water.
- *Carbon storage.* These areas are a nationally significant store of organic carbon. However, blanket bogs which are in poor condition due to past drainage are currently net sources of greenhouse gas emissions, especially carbon dioxide. Climate change may exacerbate the poor condition of blanket bogs.
- *Cultural services.* The landscape has been shaped by farming over millenia. It represents a unique cultural heritage and a much-valued area for recreation.
- *Biodiversity.* The Lake District is home to nationally important species and habitats.
- *Food provision.* This is not highly productive land in agricultural terms, as reflected by its classification as Less Favoured Area. However, producing food (particularly grazing livestock), is an important part of the local economy and culture, and represents one way of turning low grade forage into food for human consumption.

How could the existing impacts of food production on delivery of environmental protection and enhancement be addressed and what impact this might have on food/crop production?

- To resolve the tensions between food production and other ecosystem services, it will be necessary a) to reach consensus (possible at a sub-catchment scale) on what should be the priorities for land management in the Lake District and b) to reflect these priorities in the income that is available to land managers from the market and from public support. Currently, although farming influences a range of ecosystem services provided by the Lake District, the majority of these services (other than food production) do not generate income for the farmer. This has led to an emphasis on food production at the expense of other ecosystem services provided by land, despite the importance of these other services. The output from the Lake District is mostly sheepmeat and some beef, and in the EU, consumption of red meat is declining. In the UK, sheepmeat consumption has declined quite rapidly in recent years with fast rising prices. There is no impending necessity for increased output.
- Grazing changes required to improve habitat quality for biodiversity include more cattle on grass fells during summer, fewer sheep in many areas and changes to shepherding practices, and controlled supplementary feeding. Restrictions on grazing in specific areas can be an important management measure, for example to help regeneration of trees, for restoration of blanket bogs, or to prevent pollution of watercourses or erosion of banks[77].
- Efforts to enhance the condition of designated sites have therefore required significant reductions in livestock numbers. These reductions, supported by agri-environment measures (ESAs, Countryside Stewardship, Higher Level Scheme) have been contentious and divisive. Despite this, there is no doubt that in the absence of CAP support (both Single Payment and agri-environment), the impact of declining inherent marginal profitability of upland sheep farming would have been very much greater. Stocking reductions also need to be seen in the context of major post-war increases driven by CAP headage payments. An important current issue is that a number of farmers in existing ESA agreements will be coming to the end of their agreements shortly, and it is not currently clear how many of these farmers will transfer into HLS agreements (for a variety of reasons).
- Policy makers must recognise the importance of considering the wider farming systems needed to provide livestock for extensive grazing. Grazing prescriptions should not be considered in isolation but more holistically as there is the possibility that loss of infrastructure, skills, labour etc could make it difficult to increase livestock numbers again in the future – this is a concern in relation to suckler herds because as habitats improve, more grazing animals may be required to maintain key habitats in good condition.

77 Economic valuation of upland ecosystem services. Natural England (2010). http://naturalengland.etraderstores.com/NaturalEnglandShop/NECR029

- It would help to ease the tensions between food production and other ecosystem services if a) farmers received a better return for the meat they produce; and b) farmers were rewarded for the other ecosystems they provide. Currently, economic risk associated with suckler herds is a barrier to increasing extensive cattle grazing. The market is driving other undesirable changes like a move to more commercial animals which is associated with changing grazing patterns e.g. more intensification on the in bye.
- The first of these could potentially be addressed by marketing the meat as high-quality food, produced in a more sustainable way as part of a traditional farming system[78]. This would require appropriate measures of sustainability and quality allowing accurate and clear labeling, to enable consumers to make informed choices. The uplands will never compete with the lowlands in terms of volume of food produced, but the market value of the food produced could possibly be increased.
- The second point – rewarding farmers for other ecosystem services – is partly addressed through agri-environment payments. However, as mentioned above there is a question mark over the future of some agreements. Furthermore, the low profitability of extensive livestock farms means agri-environment is constrained in how much support it can provide given it is based on income forgone/costs incurred. We need to broaden the support base to include market return, environmental payments and new and innovative payments for delivery of other (currently non marketable) public goods. There is scope to develop direct Payment for Ecosystem Services schemes, particularly in the case of water quality. A good example of this approach already exists in the Sustainable Catchment Management Programme (SCaMP)[79]. Some farmers are able to generate extra household income by diversifying into tourism services, for example letting out holiday cottages – thus converting the ecosystem services of attractive landscapes etc into an income.
- Different approaches may be appropriate in other situations to that in the Lake District. For example the North York Moors National Park draft management plan[80] proposes that the North York Moors can accommodate an increase in food production whilst keeping the special qualities of the Park. However, the North York Moors differ from the Lake District in several respects (including the type of farming system) so these conclusions cannot be carried over to the Lake District.

78 For an example of this approach see the 'Eat the View' programme http://www.eat-the-view.org.uk/

79 http://www.unitedutilities.com/AboutSCaMP.aspx

80 http://www.northyorkmoors.org.uk/uploads/publication/12228.pdf

- Whilst the relationship between food provision and other ecosystem services remains a contentious issue in the Lake District, there are many positive signs that different sectors are trying to work more effectively together through a range of fora, partnerships etc. The development of the Lake District Management Plan supported by The Lakes Partnership (including a Farming and Land-use group) is one such example.

If food production were to increase in the case study areas (assuming continuation of current products/crops), what would be the likely impacts on various aspects of the environment?

- There would potentially be several ways to increase food production, for example growing more arable crops where local conditions permit; increasing the productivity of each livestock unit; or raising stocking levels. All of these could potentially have detrimental environmental consequences, depending on how/where they were implemented.
- Efforts to restore degraded habitats have required targeted (in places extensive) reductions in livestock. Livestock grazing continues to have a vital role to play. As habitats improve, more grazing animals may be required to maintain key habitats in good condition. This could mean that we see a modest increase in livestock numbers in future years. Efforts to increase livestock numbers more rapidly and ahead of improved habitat condition would halt the desired improvements in habitat condition. Any further deterioration on fell and valley bottom (enclosed) habitats may also impact further on raw water quality and carbon stewardship.
- Most land in the Lake District has inherently low production potential (by reason of physical factors like slope, soils, climate etc). An attempt to 'improve' this land and intensify production would most likely result in very little production gain and a severe reduction in other ecosystem services. It is possible that future innovations (e.g. new varieties of livestock) will allow some increase in production, but this will not overcome the intrinsic limitations of the land for food production.
- It is important to realize that the Lake District is not uniform: there is a variety of habitats, soil types etc related to altitude and other factors. Some members of the subgroup (excluding the NFU) feel that an element of spatial planning could help to minimise the impacts of future production, by focusing development on areas with the greatest potential for increased production/ least environmental sensitivity. For example it might be possible to introduced mixed farming to lowland areas that are currently under enclosed pastures, with potential benefits for biodiversity as well as productivity. However, the interconnected nature of the farming system means that this could impact on the management of livestock in the upland areas. 'Off-site' impacts of farming, such as diffuse pollution and ammonia emissions, would also need to be factored in.

- Improving the *profitability* of farming in the Lake District could potentially have positive effects on ecosystem services, for example enabling farmers to spend more time and money maintaining historic features, or restoring hefted flocks and communal grazing to areas where these practices have declined. Most of the subgroup members feel that the evidence discussed above shows that increasing the volume of production may not be the optimal way to increase farmer income, although the NFU does not support this view.

What would long term reconciliation of ecosystem services (food provisioning, biodiversity, water quality, carbon storage etc) look like in this area?

- Climate change impacts, and the need to both adapt to and mitigate climate change, are likely to mean that the uplands will look quite different in the future. Actions to mitigate and adapt to climate change could include appropriate afforestation and securing wetlands and carbon-rich soils.
- As mentioned above, the subgroup discussed how spatial planning would permit the identification of areas more or less suitable for provision of one or multiple ecosystem services. Policy levers (including regulation, advice and incentive payments) could then be targeted accordingly. Any spatial planning approach would need to involve the community and take an integrated approach to delivering a range of ecosystem services, rather than separate targeting statements for separate incentive funds. Please note that the NFU does not support this approach.
- Reconciliation demands that we develop more accountable and democratic decision making bodies that recognise the roles and responsibilities of those who produce/secure the delivery of vital ecosystem services and also the beneficiaries of these same ecosystem services. The development of landscape approaches, led by locally accountable bodies, with input from the key beneficiaries, may help develop a shared sense of purpose and help further cement the vital role that land managers need to play now and in the future.
- The Common Agricultural Policy has an important role to play in securing the delivery of public goods. Subgroup members differ in their views on the CAP. Some feel that it is not currently meeting its potential, with the majority of the budget still spent as untargeted direct payments with no clear purpose.
- A key point is that farming in the Lake District must be recognised and rewarded for <u>all</u> the services it provides, not only food, so that food provision is not allowed to dominate to the detriment of other ecosystem services.

Annexes

Annex 1: Environmental limits

This table has been compiled by the RSPB from a number of sources.

Environmental limits within which agriculture must operate	England/ UK commitments, targets and ambitions	Relevance to farming in England and the UK
1. *Preserving and enhancing biodiversity* The UK Biodiversity Indicators [a] show that many measures continue to show long-term deterioration including populations of farmland birds and woodland birds, populations of specialist butterflies, bat populations and plant diversity (in woodland and grassland, and in boundary habitats).	• In October 2010, the parties to the CBD agreed to a new set of goals and targets for the protection of biodiversity globally. They also agreed to continue to produce global and national indicators to track progress with 20 new targets (known as the 'Aichi targets').[b] • A new EU target was adopted in March 2010: 'Halting the loss of biodiversity and the degradation of ecosystem services in the EU by 2020, and restoring them in so far as feasible, while stepping up the EU contribution to averting global biodiversity loss.' • The Birds and Habitats Directives [c] provide a framework for the conservation and management of biodiversity in Europe and include a commitment to	• Biodiversity is vital to farming, e.g. in maintaining a 'wild gene pool' from which future crop improvements can be developed and as an integral part of ecosystem functioning. • Declining species in the UK include some farmland specialists dependent on certain types of farming (e.g. corncrakes need low-intensity pasture). • We know that even with current conventional and highly productive systems, action can be taken now to deliver for more generalist but declining species and wider biodiversity (eg through good application of agri-environment schemes). We currently have more in our toolbox for arable systems than for intensive grassland systems. • Farming has a vital role in enabling wildlife to adapt to climate change (as per the recommendations of the Lawton review [e]): incorporating 'stepping stones' such as flower-rich

Environmental limits within which agriculture must operate	England/ UK commitments, targets and ambitions	Relevance to farming in England and the UK
	maintain the populations of all wild bird species across their natural range. • Government sets out its ambitions for the UK in the NEWP [d] "We will work to improve the quality of our natural environment and will aim to halt the decline in habitats and species, degradation of landscapes and erosion of natural capital." • In England, Government's aim by 2020 is to "halt overall biodiversity loss, support healthy well-functioning ecosystems and establish coherent ecological networks, with more and better places for nature for the benefit of wildlife and people." [f]	field margins to enable wildlife to move around the landscape; 'softening the matrix' to enable the survival of more widespread species throughout our farmed landscape.
2. *Maintaining ecosystem services* The National Ecosystem Assessment [g] concluded that "The natural world, its biodiversity and its constituent ecosystems are critically important to	• See above	• Farming depends on a range of ecosystem services including pollination and nutrient cycling. • Agricultural practices affect provision of ecosystem services. Of the services delivered by enclosed farmland and grassland, water supply; wild species

Environmental limits within which agriculture must operate	England/ UK commitments, targets and ambitions	Relevance to farming in England and the UK
our well-being and economic prosperity" but "The UK's ecosystems are currently delivering some services well, but others are still in long-term decline."		diversity; soil quality and pollination have declined since 1990[89].
3. *Nitrogen pollution* The European Nitrogen Assessment [h] highlighted that "the increased use of reactive Nitrogen (Nr) as fertilizer allows a growing world population, but has considerable adverse effects on the environment and human health", concluding that "the overall environmental costs of all Nr losses in Europe outweigh the direct economic benefits of Nr in agriculture."	• The EU Water Framework Directive came into force December 2000 and became part of UK law December 2003. It commits Member States to achieve good chemical and ecological status all waterbodies by 2015. • The Nitrates Directive forms an integral part of the Water Framework Directive. It requires Member States to designate Nitrate Vulnerable Zones; establish Action Programmes, to be implemented by farmers within NVZs on a compulsory basis; and establish codes of good agricultural practice, to be implemented by farmers on a voluntary basis.	• Some of the nitrate applied to agricultural land as fertiliser is lost from the farming system. This is a problem both in terms of pollution and inefficient use of resources. • Around 60% of nitrate in English waters originates from agricultural land (Defra).
4. *Climate change mitigation* To avoid catastrophic climate change,	• Under the Kyoto Protocol, the UK is bound to reduce its GHG emissions by 8%	• Farming and changes in land use are responsible for about 7% of UK GHG emissions.

Environmental limits within which agriculture must operate	England/ UK commitments, targets and ambitions	Relevance to farming in England and the UK
developed countries need to reduce GHG emissions by an estimated 25- 40% below 1990 levels by 2020, and 80-95% below 1990 levels by 2050, in order to stabilize below 450 ppm CO2-eq concentration.	compared to 1990 levels by 2012. • The EU is committed to reducing greenhouse gas emissions by 20% by 2020. • The Climate Change Act 2008 sets a unilaterally binding target for the UK to reduce emissions by at least 34% by 2020 and at least 80% by 2050 compared to 2008 levels.	• But this excludes the role of farming in determining the net emissions/sequestration of carbon from agricultural soils. The potential for protecting and building important carbon stores on agricultural land is likely to be significant, with consequent benefits for resource protection and biodiversity. • Over 37 billion tonnes of carbon are estimated to be currently stored in UK soils and forests. Land use decisions and management practices can increase or decrease the size of this carbon store. • Decisions taken by farmers in the UK affect emissions elsewhere, e.g. growing soy for animal feed on cleared land in the tropics causes emissions. • Farming must also contribute to the adaptation needs of wider society, e.g. through rationalising water use, storing flood water etc, as well as helping to mitigate against further climate change by storing carbon.
5. *Water supply* The Water Exploitation Index is a measure of what proportion of available water is used by	• The European Water Framework Directive came into force in December 2000 and became part of UK law in December	• Agriculture depends on an adequate supply of water at the right times in the growing season. • Overall, farmers use less than 1% of the total amount

Environmental limits within which agriculture must operate	England/ UK commitments, targets and ambitions	Relevance to farming in England and the UK
people. Water resources are considered to be 'under stress' if this index is more than 20%. Over England and Wales as a whole, the index is 10%, but South East and Eastern England can be classified as an area 'under stress from water abstraction', with more than 22% of freshwater resources abstracted. [j]	2003. It commits Member States to achieving good chemical and ecological status in inland and coastal waters by 2015.	of water abstracted in England and Wales for spray irrigation. However, in East Anglia abstraction for irrigation can average 20% of the total over a typical summer. Water used for irrigation is nearly all used by crops or lost through evaporation, so the environmental impact is greater than other uses (e.g. electricity generation) where water is returned after it has been used.
6. *Phosphorus supply* Phosphorus is a finite resource. According to the Soil Association, "the supply of phosphorus from mined phosphate rock could 'peak' as soon as 2033, after which this non-renewable resource will become increasingly scarce and expensive." [l]	• Defra's food security assessment includes an indicator on phosphate rock reserves [k], but no specific targets.	• Phosphorus is an essential nutrient for all crops. Modern intensive agriculture is largely dependent on phosphate fertiliser derived from mined phosphate rock. • As for nitrate, the loss of phosphorus from farming systems is a cause of both pollution and agricultural inefficiency.

References for annex 1

a) http://jncc.defra.gov.uk/page-1824

b) http://www.cbd.int/decision/cop/?id=12268

c) http://jncc.defra.gov.uk/page-1372

d) http://www.defra.gov.uk/environment/natural/whitepaper/

e) Making Space for Nature: A review of England's Wildlife Sites and Ecological Network. Lawton 2010

f) Biodiversity 2020: A strategy for England's wildlife and ecosystem services, Defra 2011

g) http://uknea.unep-wcmc.org/Resources/tabid/82/Default.aspx

h) http://www.nine-esf.org/ENA-Book

i) IPCC Fourth Assessment Report: Climate Change (2007)

j) Water resources in England and Wales - current state and future pressures. Environment Agency 2008

k) UK Food Security Assessment: Detailed Analysis. Defra (2009, updated 2010)

l) A rock and a hard place: Peak phosphorus and the threat to our food security. Soil Association 2010

Annex 2: A note on Sustainable intensification and related concepts

Sustainability

The concept of sustainability comprises environmental, social and economic aspects, and is described in the Foresight report on the future of food and farming[81] as follows:

The principle of sustainability implies the use of resources at rates that do not exceed the capacity of the earth to replace them. Thus water is consumed in water basins at rates that can be replenished by inflows and rainfall, greenhouse gas emissions are balanced by carbon fixation and storage, soil degradation and biodiversity loss are halted, and pollutants do not accumulate in the environment. Capture fisheries and other renewable resources are not depleted beyond their capacity to recover. Sustainability also extends to financial and human capital; food production and economic growth must create sufficient wealth to maintain a viable and healthy workforce, and skills must be transmitted to future generations of producers. Sustainability also entails resilience, such that the food system, including its human and organisational components, is robust to transitory shocks and stresses. In the short to medium term non-renewable inputs will continue to be used, but to achieve sustainability the profits from their use should be invested in the development of renewable resources.

A failure in any one of the three aspects of sustainability (environmental, social or economic) means that the system overall is not sustainable. The Foresight Report states that "*many systems of food production are unsustainable",* highlighting the problems of soil erosion and degradation, over-extraction of water, heavy reliance on fossil fuel-derived energy and emissions of greenhouse gases and other pollutants. Achieving environmental sustainability is essential to human survival and wellbeing, as well as being a prerequisite to future productivity of agriculture.

Sustainable Intensification

If there is a need to increase total food production, and given that there is very little scope to expand the agricultural area, it follows that globally we will need to produce higher yields on our existing agricultural land, i.e. intensification. Sustainable Intensification is described in the Foresight report as "*simultaneously raising yields, increasing the efficiency with which inputs are used and reducing the negative environmental effects of food production. It requires economic and social changes to*

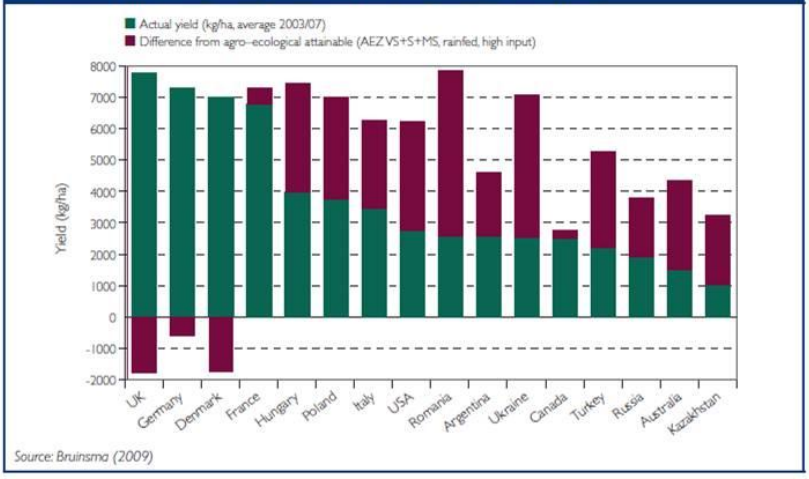
[81] Foresight. The Future of Food and Farming (2011) Final Project Report. The Government Office for Science, London.

recognise the multiple outputs required of land managers, farmers and other food producers, and a redirection of research to address a more complex set of goals than just increasing yields." Although "intensification" is often equated with increased agricultural inputs and technological innovation, it can equally well be applied to an intensification of the skills, knowledge and labour applied to farming. Sustainable intensification is not possible in all situations, for example where the current level of farming 'intensity' is already causing environmental degradation, or where low-intensity farming is critical to maintaining biodiversity or other ecosystem services such as carbon sequestration and water management. Rather than attempting to increase yields on any given area of farmland, we should be looking to achieve the optimum delivery of ecosystem services from this land. In some places this may involve decreasing food production to allow other ecosystem services to be delivered, while in others it may be possible to increase production as well as other ecosystem services.

At a global scale, the Foresight report does not advocate increasing production in all places as a solution to food security. The graph below, which is taken from the Foresight report, illustrates where in the world there is potential to increase wheat yields. Current yields in the UK are higher than the theoretical maximum - partly explained if we assume that wheat is only grown on the most productive land, which gives higher yields than an average taken across varying quality land.

Figure C5.1 shows the difference between actual wheat yields and those that should be attainable given the prevailing agro-ecological conditions, in a number of high- and middle-income countries. It demonstrates the very substantial potential for growth in productivity which might be achieved if socio-economic, institutional and political conditions were more favourable to the uptake of new technologies and practices. It implies that in many places, under the right conditions, yields could double. Major investment over the long term would be required in infrastructure, market development and technology adoption in many of these countries to push actual yields closer to this potential.

Figure C5.1: Actual and agro-ecologically attainable yields for wheat in selected countries. AEZ denotes agro-ecologically attainable national average wheat yield[4]



Source: Bruinsma (2009)

3 See Project Report C2 (Annex E refers)

4 This is obtained from an average value of very suitable (VS), suitable (S) and moderately suitable (MS) yields attainable under rainfed and high-input farming conditions. These values are based on the Global Agro-ecological Zones (GAEZ) analysis by Fischer (2009). Where the AEZ is negative this denotes that those countries (UK, Germany and Denmark) have actual yields that are higher than those attainable for their agro-ecological endowments under rainfed and high-input conditions.

Land sparing

This concept is related to Sustainable Intensification. If it is possible to raise yields on existing farmland, then this theoretically reduces the need to expand the agricultural area, allowing other land to be 'spared' for biodiversity. The converse is 'land sharing', where wildlife-friendly agriculture enables both biodiversity and food production to be delivered from the same land, although usually at the cost of some reduction in yield. There is a continuum between extreme situations of land sparing or sharing, and the concepts can be applied at any scale. For example, land sparing at a global scale might involve increasing production in Europe to spare remaining pristine habitats in South America; while at a farm scale a farmer might manage his most productive fields intensively to maximise yields while sparing the margins and less productive patches for wildlife. Land sparing/ sharing should not be taken as two mutually exclusive options for the future of land management policy: each situation should be judged on its own merits. The optimal approach in a particular situation will depend on a variety of factors, including among many others:

- the relationship between farming practices and biodiversity. Much of the UK's wildlife is strongly associated with farmland, whereas in places like the tropics farming might be inimical to the majority of native wildlife;
- negative externalities of farming such as pollution that may affect the 'spared' land; and
- whether or not mechanisms exist to protect the 'spared' land from future agricultural expansion or other development.

Addressing food security challenges

The high-level conclusions of the Foresight report were briefly as follows:

1. To feed 9 billion people, action is needed on <u>all</u> of the following simultaneously:
    - More food must be produced sustainably
    - Demand for the most resource-intensive foods must be contained
    - Waste must be minimised
    - Political and economic governance of the food system must be improved
2. Addressing climate change and achieving sustainability in the global food system are dual imperatives: a redesign of the whole food system is necessary
3. To end hunger, more priority must be given to rural development and agriculture as drivers of income growth, with incentives provided to address malnutrition and gender inequality, and a reduction in subsidies and trade barriers that disadvantage low-income countries.
4. Policy options should assessed using a strong evidence base to enable informed decisions.

5. Food self-sufficiency is not a viable option for nations to contribute to global food security. Food system governance must maximise benefits of globalisation and distribute them fairly.

Annex 3: Green Food Project geographic case studies work strategy

Objectives

DEFRA's Green Food Project (GFP) has been convened in order to help deliver on a Government commitment in the Natural Environment White Paper to: "bring together government, industry and environmental partners to *reconcile how we will achieve our goals of improving the environment and increasing food production*."

The overall aim of the GFP is "to contribute to a coherent vision for the future of the food and farming industry, and a trajectory for reaching this, with conclusions about specific and realistic objectives." The group intends to focus on the period of the next 30 – 40 years.

Given the potentially vast scope of this project and very short timescales (the Minister is committed to publishing findings by June 2012), the steering group has agreed to focus on test cases that will enable us to approach the question from different angles: agricultural sectors (dairy and wheat), end-products (bread and curry) and specific geographical areas (Lake District, South West lowlands and North Norfolk).

The current strategy relates to the geographic case studies. Through these geographically specific case studies we hope to describe and analyse the current and potential future interactions between food production and delivery of a range of priority environmental goods and services, building on the groundbreaking work of the National Ecosystem Assessment, site-specific studies and datasets. As with the NEA, we intend to take an ecosystem services approach, treating food production as one of a range of ecosystem services. Through these case studies we aim to address the following questions for each study area:

1. What are the current tensions and synergies between current food/crop production and delivery of environmental protection and enhancement objectives?
2. What are the ecosystem services of particular local or national importance?
3. How could the existing impacts of food production on delivery of environmental protection and enhancement be addressed and what impact this might have on food/crop production?
4. If food production were to increase in the case study areas (assuming continuation of current products/crops), what would be the likely impacts on various aspects of the environment?

5. What would long term reconciliation of ecosystem services (food provisioning, biodiversity, water quality, carbon storage etc) look like in each case study and how does this differ between each case study according to local conditions?

This project will consider food production as one of a range of ecosystem services that can be delivered from the case study areas, including cultural services (such as landscapes, biodiversity), and regulating services (such as clean water, flood risk mitigation, climate change mitigation) and the natural resource base which underpins them - see figure 1. The range of ecosystem services we could try to address is significant, so for the purposes of this (very time limited) work we will focus our efforts on those that are measurable (or where there are reasonable proxies) or which are the focus of specific legal or international commitments. However we should include ecosystem services that are particularly critical or relevant to the case study areas and the farming systems within them:

Provisioning services: Food

Regulating services: water quality, flood risk, pollination and pest control (services of biodiversity), carbon storage

Cultural services: wildlife, landscape, [particularly within AONB and National Park examples]

We also hope to explore in what ways increasing production, securing economic growth and improved profitability for individual farmers and land owners within our case study areas may be aligned with each other, through farm-level case studies where possible.

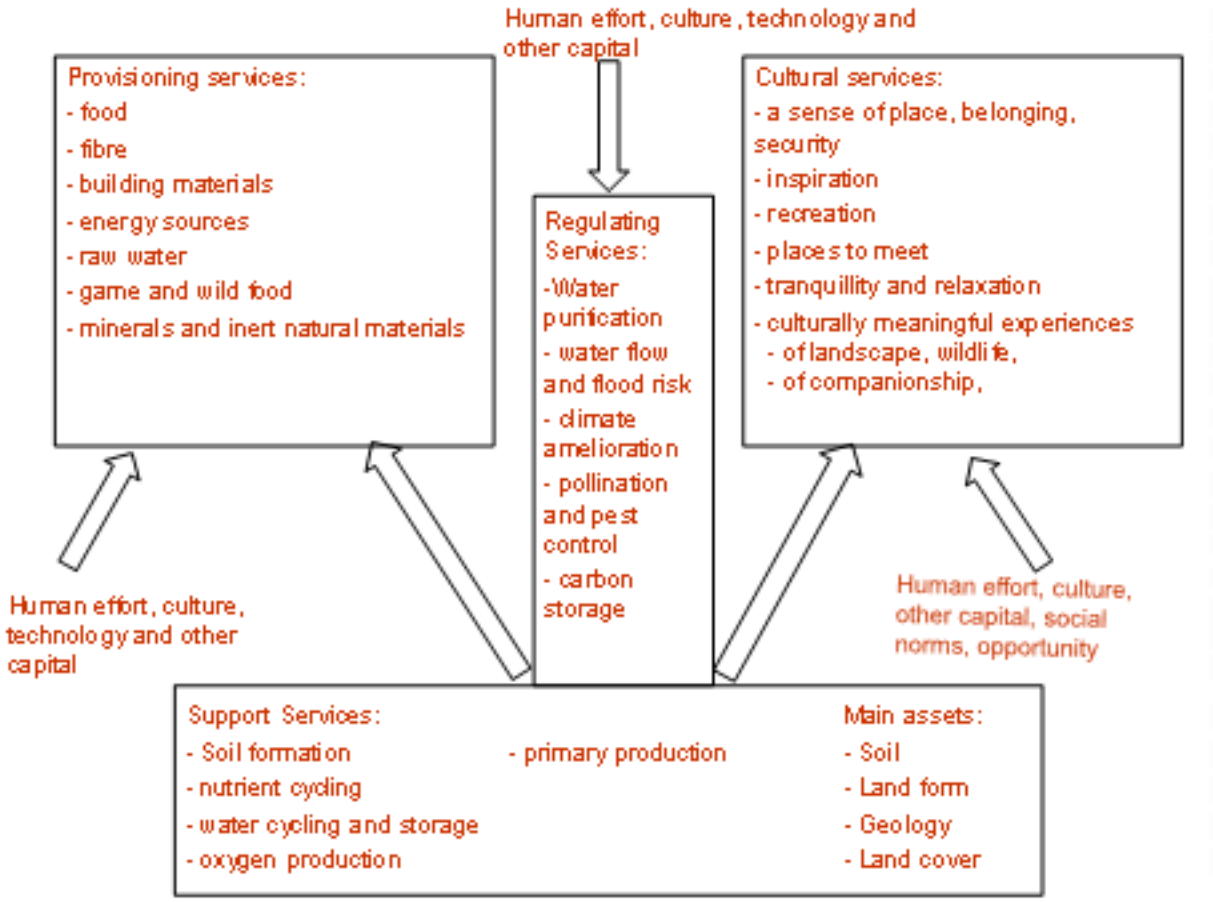


Figure 1: Ecosystems Services

Outcome/ end product

The output of this project will be a report, in the form of text, maps and data, on the current situation in the case study areas in terms of provision of food production and other priority ecosystem services. It will include a description of the interactions between food production and other ecosystem services (both tensions and synergies). The subgroup will progress as far as possible towards answering the questions set out above; but we recognise that **in the time available it may not be possible to carry out the detailed scenario modelling needed to answer these questions fully.** At the least, we will aim to provide an insight into which zones within the study areas are critical for food production and other ecosystem services, and highlight any key tensions. The report may include policy recommendations for Defra if these arise out of the work and there is clear consensus within the subgroup, but this will not be the main focus of our work.

Defra has set up a 'synthesis group' to coordinate evidence and ensure consistent information is used across subgroups, and to assist the steering group in finalising the overall project conclusions. The synthesis group has prepared a list of questions to guide the work of the subgroups – see separate document.

The subgroup has been asked to report its findings to the GFG steering group on 26th March. The overall GFG project is aiming to produce a report by June.

We should try to secure agreement from the Steering group for more reasonable time for delivery of this work, since we believe there is real value in describing and analysing these issues in a collaborative way, which will ultimately enable us all to develop solutions – at practical and policy levels.

Method

Three case study regions have been selected:

- Norfolk coast
- South West lowland
- Lake District

It is proposed that the subgroup focuses at a different scale within each study area, so we can draw out the different interactions between productivity and environment that exist at different levels, and also to illustrate that different scales of data are appropriate for different purposes. The following is suggested:

North Norfolk

Farm-scale case studies, using at least one conventional arable/mixed farm and one organic arable/mixed farm within the region. The aim will be to compare/ contrast ways of reconciling food production and environment within different farming systems. We may supplement these studies with information from the EA/ NE test catchments work (e.g. Wensum catchment), to draw out issues such as water quality that are less obvious at farm level.

Possible data sources:

- Farm level data where available
- NE farm case studies in the area
- Information from other farmers in the area with whom the RSPB or other subgroup members have a good working relationship.
- Data from EA/ NE test catchment work
- Any other information provided by local stakeholders
- National GIS data layers (soil, land cover etc) provided by Defra.

- NEA and other relevant studies exploring ecosystem services within lowland arable systems, particularly within coastal setting and within AONB

South West

Catchment-level case studies, building on the work of the SW Rivers Trust, with a focus on lowland grassland.

Possible data sources:

- Maps and data layers provided by Dylan Wright at the SW Rivers Trust
- Defra-funded studies on lowland dairy farming from this area or other catchments
- Any other information provided by local stakeholders
- National GIS data layers (soil, land cover etc) provided by Defra.
- NEA
- Other studies from similar systems on the interactions between food production and environmental protection and enhancement

Lake District

Landscape-scale study using the National Park as the defined study area. This has the advantage that there is likely to be a lot of information and case studies already available.

Possible data sources:

- Information provided by the National Park Authority
- Any other information provided by local stakeholders
- National GIS data layers (soil, land cover etc) provided by Defra.

For each study area, the subgroup will need to:

1. Identify the available data sources and obtain access to these as needed.
2. Identify and contact key stakeholders in each study area (this could be colleagues or external contacts of subgroup members).
3. In discussion with these contacts and with reference to the data sources available, agree a) which physical areas to focus on (e.g. individual farms, specific river catchments); and b) which ecosystem services to include within the study. This will depend on which services are considered critical by local stakeholders; any site designations such as SSSI, Nitrate Vulnerable Zone etc, as well as what data are available for the study areas. We should aim at least to capture an example of a provisioning, regulating and cultural service for each study area.
4. We will also need to decide how best to examine the socio-economic aspects of the case study, e.g. income from farming and other land uses, describing the operation

of supply chains, interviewing stakeholders about their business plans/ aspirations/ expectations for the next 40 years.

Once the terms of the case study have been agreed as above, tasks will include:

5. Producing maps to show current land uses and key ecosystem services in the case study region, highlighting which areas are critical for certain ecosystem services.
6. Collating and writing up the data (including information provided by the local stakeholders) on the focal areas within the region (i.e. the individual farms/ catchments or the National Park).
7. Carrying out a literature review on the interactions between food production and the other ecosystem services. This could include the National Ecosystem Assessment as well as more site-specific information. It could include 'expert opinion' as well as published literature, e.g. interviews with the local stakeholders.

Possible further tasks if time permits:

8. Review the projected impacts of climate change for each area over the next 30 - 40 years (this may be particularly significant for coastal regions in the Norfolk case study)
9. Generate two alternative 40-year scenarios: optimising food production or optimising the full range of ecosystem services, drawing on the findings of the above work:
    a) Establish where within the study area there is scope to increase food production without leading to critical negative impacts on other ecosystem services (bearing in mind projected climate change impacts).
    b) Produce a map or series of maps illustrating how priority ecosystem services could be optimised over the long term (bearing in mind projected climate change impacts).

Annex 4: RSPB's Hope Farm – extract from an internal report

Introduction

The Hope Farm project has its origins in the RSPB's concerns about the decline of the populations of common and widespread birds of farmland (e.g. grey partridge, lapwing, skylark, linnet, yellowhammer, corn bunting and tree sparrow), and its goal to see those declines reversed. In 1999, the RSPB bought a farm and set up the Lowland Farmland Project, with an objective to *"Trial, demonstrate and advocate new farmland management techniques that favour farmland birds".*

Hope Farm is a 181.4 ha predominantly arable farm. The soil is a calcareous clay loam of the Hanslope series. In 1999, Hope Farm had a rotation of autumn-sown crops. Up to the 1970s, it was a mixed farm with a beef cattle enterprise grazing about 35 ha of permanent pasture with short-term grass leys integrated into the arable cropping area, and spring sowing on three quarters of the arable land. Spring sowing of arable crops continued into the 1980s with crops including barley and beans. The area of spring cropping then underwent a significant decline, replaced by autumn-sowing, and the livestock enterprise ended.

2000-2005

During the first five years of RSPB ownership the farm ran a three-year rotation of two crop types – winter wheat and winter oilseed rape (1st wheat, 2nd wheat, oilseed rape). In addition, just over five ha of permanent pasture were retained, grazed by horses and sheep. Crop yields and income remained relatively stable

The overall strategy for land management at Hope Farm initially included a two-year period of baseline data collection (years 1 and 2) involving a range of taxa, including birds, butterflies, plants, mammals, and fungi. This was followed by an experimental phase (years 3 to 5), primarily researching skylark plots. The option is now available within the English Entry Level Stewardship available to all farmers across the country.

Common Bird Census (CBC) style monitoring provided the basic measure of breeding bird numbers at Hope Farm. Using the same 19 species that comprise the Government's former Quality of Life farmland bird indicator, we were able to calculate Farmland bird indices (FBI) specific to Hope Farm. The FBI for Hope Farm rose by 44% (2004). The species showing the largest increases at Hope Farm were skylark (increasing from 10 to 27 pairs) and linnet (6 to 14 pairs).

2005 – 2009

The second five-year strategy period built on the success of the first five years. We focused on improving the demonstration value of the site, developing further research which included management techniques for floristic grass margins, comparing the bird usage of broadcast vs. minimum tilled oilseed rape and monitoring vegetation structure of skylark plots created by spraying with herbicide. In addition, we created new habitats including three wet features examining diffuse pollution issues.

The 2009 breeding bird surveys show a continued marked increase with the Farmland Bird Index now standing 177% higher than in 2000. With the exception of 2008, there have been year-on-year increases in the index.

Wider biodiversity

RSPB repeated several of the original baseline surveys to assess how the management on the site is affecting wider biodiversity, these included plant and bat surveys. Independent botanists surveyed both the field centres and crop edge to assess the changes in floral populations. Results show that the floristic diversity of the field margins increased with 168 species recorded in 2009, compared with 103 in 2000. This included the nationally scarce broad-leaved spurge and slender tare. Whilst this increase is partly explained by the RSPB deliberately sowing some species, like ox-eye daisy to encourage butterflies and bees, more than 40 new species were recorded which were not deliberately sown.

2010 -2015

The aim of the work will be:

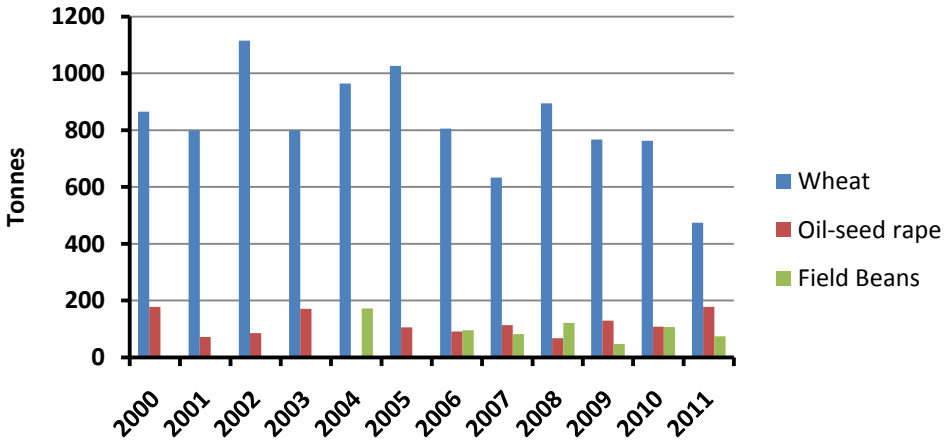
a) Establish a robust baseline monitoring programme in consultation with conservation science, water and agricultural policy, to estimate current levels of nitrate, phosphate and soil particulate entering watercourses on Hope Farm. This programme will need to be extensive, incorporating regular and peak rainfall sampling.

b) Develop a series of spatially-explicit scenarios for future land use/management at the farm. This will help us assess where best to target diffuse pollution measures to maximise their benefit for both biodiversity, diffuse pollution and carbon sequestration.

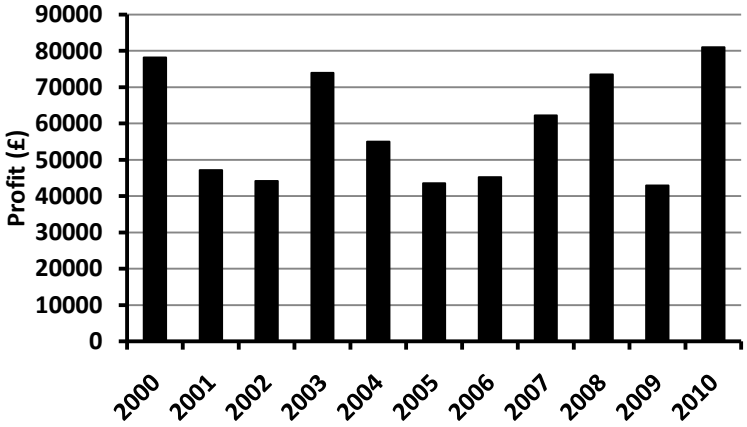
c) Demonstrating best practice on an arable farm to policy makers and farmers, including how this has been achieved and assessing the financial, yield and biodiversity impacts.

d) Trial new methods for reducing diffuse pollution on our reserves and at Hope Farm.

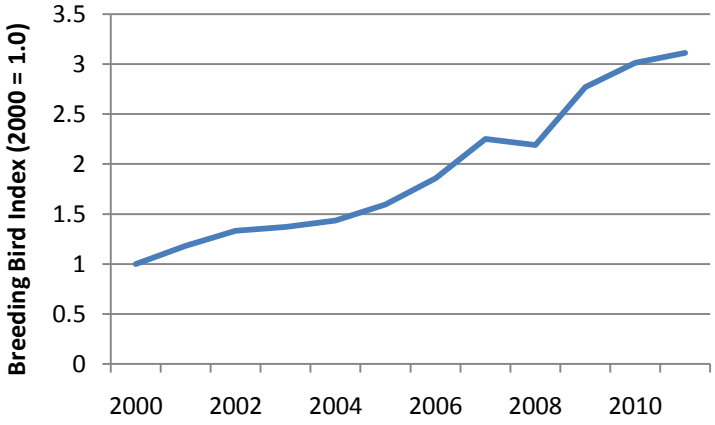
Crop tonnage produced by Hope Farm



Profit at Hope Farm



Breeding bird Index at Hope Farm



Annex 5: Some key predicted impacts of climate change on agriculture in the UK

Predicted change	Likely impacts on agriculture and knock-on effects
Rising atmospheric CO_2 concentration	The predicted increase in CO_2 up to 2050 should increase photosynthesis (potentially increasing yields), affect nitrogen use efficiency, and improve the efficiency of water use by crops. The ability of crops to benefit from elevated CO_2 depends on both crop management and genotype. Plants grown at elevated CO_2 can have higher carbohydrates and lower nitrogen, with consequences for product quality.
Higher temperatures	Major and variable effects on both yield and quality. For cereals, a shorter growing season and reduced yields are likely. Altered timing of harvest window for some crops. Increased costs for storing crops, e.g. need for refrigeration. Implications for livestock welfare.
More frequent extreme events (heat waves, frosts, drought, waterlogging, wind, hail, inundation)	Likely to be one of most serious impacts for agriculture in the short term. Significant impact on production, either as yield or quality loss. Crops that require continuity of supply e.g. salad leaves are particularly vulnerable.
Changes in precipitation patterns and water availability. By 2050, river flows in summer/ autumn could decrease by 50% - 80% in some areas.	Water availability will be a major determinant of future agricultural practice. Wetter winters will mean continued need for winter housing for livestock.

Predicted change	Likely impacts on agriculture and knock-on effects
Pests and diseases. Pests may be able to grow faster and produce more generations per year. Wind may assist dispersal	Increased costs associated with pests (whether as loss of production or increased spending on pest control). Control by pesticides, biological control agents or host plant resistance is likely to be affected, often negatively, by the increased frequency of extreme climate events.
Changes in the quality of soils, particularly an increasing level of soil degradation	Negative impact on yields. In extreme situations, agriculture becomes unviable.
Increased productivity of pastures	Increase in the annual grazing period by up to 5 weeks for cattle, and 7 weeks for sheep. Likely to be more pronounced in northern regions. Earlier finishing of animals, finishing becomes viable in new areas. There may be changes in greenhouse gas emissions from livestock as a result of more grass in their diet, including increased methane but reduced nitrous oxide emissions. The predicted net effect is to decrease the global warming impact, but there will be variations between regions.

The above table is a summary of findings from the following studies:

Vulnerability of UK agriculture to extreme events, 2008.
Climate change impacts on the livestock sector, 2009.
Scoping study on the potential impact of environmental factors associated with climate change on major UK crops, 2009.
A Research and Innovation Network supporting adaptation in agriculture to climate change, 2009. Adapting to climate change: EU agriculture and forestry. House of Lords EU Committee, 2010.

Annex 6: Comments received on specific case study questions

NB: the above report also draws the authors' own knowledge and on opinions expressed in verbal discussions. The following table is therefore a compilation of specific answers to the questions posed; not a comprehensive summary of all input received to this project.

Norfolk case study

Questions	*Organisation*	*Response*
What are the current tensions and synergies between current food/crop production and delivery of environmental protection and enhancement objectives?	*CPRE*	The 'current' tensions between food crop/production and delivery of environmental protection and enhancement have been evident for 20 years or more. It is only in recent years that major steps have been taken to ameliorate the problems. The principal tensions arise from the way that land and water resource is used, and the interactions between the two. However the 'people' element also plays a very large role for water, its usage and the return of waste water to the natural environment. In the East of England, with its dry climate, water is a finite resource, with the need from agriculture, landscapes and wildlife, and domestic and other uses of the public water supply all competing and tending to peak in the summer months. There are quantity issues for all three; and quality issues arising from agriculture for both the natural environment and the public water supply; and for the natural environment the standards of the water companies waste water treatment works and discharge into the natural environment. The main synergy is that farmland is the receptor of rainfall which percolates into the underground rock strata, and provides the 'reservoir' source for all human use directly by borehole or indirectly by surface abstraction from rivers.

	NFU	One of the tensions is that conservation summer grazing is seen as desirable by many local groups with an interest in the conservation benefits but the grazing marshes are of poor quality, there is no profit in this type of farming system, there is no winter housing and the infrastructure is not available.
What are the ecosystem services of particular local or national importance?	*CPRE*	Landscapes and wildlife, particularly in coastal areas, are of local and national importance for enjoyment and mental health. The tourist sector is the single largest sector in financial terms not just in the coastal and AONB areas, but in the county as a whole.
	NFU	This is a very variable county. The coastal strip of N Norfolk is characterised by salt marsh, eroding cliffs and pasture. The county is also an important tourist area, with coastal paths and national routes. It is also an important area for barley, particularly in the coastal area, where British beer is an important product. It is also agriculturally diverse, with vegetable production also being very important. The pea vining industry is also of importance. And local food production is growing in the area, with restaurants in local towns such as Holt providing a market for this local produce. Migrating birds are also a feature in this area. There are also a number of sensitive chalk rivers.
How could the existing impacts of	*CPRE*	Many of the necessary policies and legislation are now in place to offer a significant reduction

food production on delivery of environmental protection and enhancement be addressed and what impact this might have on food/crop production		in the tensions between food production and other ecosystem services are now in place and are beginning to show much benefit. But there is a concern that the Government, faced with a weak and debt-laden economy, will loosen policies and legislation on the grounds of 'affordability'. In fact on a long term survival basis we cannot afford to do this. The advisory, persuasion and regulatory roles of the Environment Agency and Natural England are crucial to the long term sustainable use of land and water upon which we all depend. We are in a long haul situation here, not a fits and start approach.
	NFU	There are some large farms which can invest, rely on advisers and agronomists and use the latest technologies. This is a good area to further investigate how we can produce more and impact less. However, it is difficult to see how conservation grazing in North Norfolk can be viable without further investment in the infrastructure needed (e.g. housing and abattoirs).
	Defra science team	Agri-environment schemes, along with cross-compliance, regulations and designations, already address some of the impacts, whilst allowing food production to continue. However, a recent review funded by LUPG (Cao et al 2009) estimated that the need for environmental land management payments in England was about three times the current budget. An increase on this scale is extremely unlikely, so it is important to look for alternative mechanisms for rewarding environmental land management.

If food production were to increase in the case study areas (assuming continuation of current products/crops), what would be the likely impacts on various aspects of the environment?	*CPRE*	As well as looking to increase food production when there are still many strains in the system, questions should be asked on the use on the current levels of food production; consumer attitudes and expectation, and the role and influence the major food retailers. Much of the food produced is wasted at the point of production, in distribution and most all, in the home. It is not acceptable to provide unlimited choice to consumers in a system where so much of the financial and environmental costs are externalised or passed on to the next generation.
	NFU	This is a very difficult question to answer without having more information to hand about predicted increases. At best, we could only speculate.
	Defra science team	We would need to consider HOW food production was being increased. That is, the development and application of new and/or different technologies, systems and practices will have differing impacts – some positive, some negative.
What would long term reconciliation of ecosystem services (food provisioning, biodiversity, water quality, carbon storage etc) look like?	*CPRE*	The long term reconciliation between the ecosystem services, and climate change concerns, would be greatly eased by changes in dietary patterns such as less emphasis on meat in the diet, more local sourcing and seasonality. But the core aim must be to ensure high standards in the use and care of land and water, and the needs of our natural environment are not treated as an optional extra.

	NFU	The suitability of the landscape and the market for high value local produce means that agriculture are likely to continue to dominate in this area. the farming in North Norfolk is quite advanced.
	Defra science team	A considerable amount of research has looked at aspects of this problem in lowland faming systems. There is information on potential win-wins (e.g. benefits of pollinators, other invertebrates and soil structure), some information on the direct benefits of wildlife for agricultural production, especially in relation to beneficial insects, and a growing body of experience on how to manage trade-offs, but an effective synthesis of this knowledge is needed. In lowland areas there are some obvious synergies around increased resource efficiency leading to improvements in water quality. The conservation of farmland biodiversity can also be accommodated, to some degree by the use of the least productive land for intensive conservation management.

Lake District case study

Questions	*Organisation*	*Response*
What are the current tensions and synergies between current food/crop production and delivery of environmental	NFU	A recognised current tension is that a number of farmers in existing ESA agreements will be coming to the end of their agreements shortly. Our understanding is that some 40 % of current ESA agreement holders will not be offered an HLS agreement.

protection and enhancement objectives?		
	SA	The continuing degradation of upland areas by a combination of over-grazing and lack of diversity in grazing (mono-cultural grazing by sheep instead of a mix of cattle and sheep). The conflict between mainstream agricultural policies emphasising production per hectare, and the main and growing economic interest in landscape and wildlife via tourism, which require more varied and lower (but better quality) meat production – the same solution as solving the key environmental problems.
	WCL	Mainly the issues focus around stocking levels. Demand for lower stocking on the fells and the re-introduction of cattle that the previous ESA schemes removed (even though the farmers cautioned it would not be beneficial). The farmers are obviously against lower stocking, but from a cultural/heritage ecosystem angle there are issues for the heritage around common land, and in particular hefting. There is pressure for off wintering of stock, but the commoners argue this is reducing the hefted flocks which are already at a dangerously low level. There is also pressure for more woodlands but farmers see that as a loss of productive land. Where is the balance between food production and all the other ecosystem services? A lot of the arguments revolve around what are

		the uplands for and therefore what are the priorities? There is no real consensus, so farmers favour food production, while the agencies push for biodiversity, water companies push for cleaner water, carbon and peat issues; the public want high quality landscapes, tranquillity, recreation and sport. In food terms, the uplands provide 'slow food' - they will never compete with the lowlands in terms of volume of food produced, but are integral to the lowlands in terms of stratified sheep system that traditionally operated but is now breaking down - i.e. start the sheep in the uplands, then finish and fatten them in the lowlands. On pure economic grounds the uplands will always fair badly compared to lowlands. However, in terms of sustainable, environmentally friendly food production, slowly produced food, less transport, less fertiliser, nicer lifestyle, etc may be a way forward - eat the view in other terms. Market the products as things that are produced sustainably, and contribute to maintaining landscape and other ecosystem services etc. so that the produce price goes up. Linked to the above, the lowlands get far more public subsidy for food than the uplands - which are disadvantaged in terms of lower payment rates. If this was changed to reflect the fact that the uplands deliver so many, if not all, ecosystem services, and often for the nation (national parks; water to other areas, cultural heritage etc.), then the costings would be very different and in turn the reward for producing food, but also essential ecosystem service provision would be much more balanced and help provide income to the farmers who are

		essential for ecosystem service delivery.
	Westcountry Rivers Trust	Although the area is highly varied, profitable food production generally seems to be very difficult in the area due to a combination land quality and other natural features. Much land improvement would be/is required for nationally competitive food production. The ambition of improving land generally in this area to produce food competitively would be/is at odds with the successful delivery of other Ecosystem Services, which have national and international value and provide significant benefits through the visitor economy. Additionally the area has a vital role for water purification and storage, which is not generally compatible with intensive farming unless local spatial planning is used to focus farming away from areas that are useful for providing wider Ecosystem Services. Accordingly, we feel local ecosystem based spatial planning is required to establish land suitability for different purposes in order to inform available incentive payments. Agriculture is a small aspect of the economy 8% but controls the delivery of many of the ecosystem services, which comprise the wider regional economy and yet only predominantly only receives income from food production markets. We feel farming should be linked to the wider economy in recognition of the services it can provide and we feel that Ecosystem Service Based Spatial planning should be used to target incentives for deintensification.
	RSPB	Tensions - stocking levels; poor understanding and acceptance of impact of high grazing pressure on habitats and associated delivery/maintenance of a suite of ecosystem

		services. Failure to note importance and workings of commons. Conservationists slow to understand that farming in fells reliant on finishing animals away from fells. Synergies - increased awareness of need to work together to secure more economically viable and environmentally sustainable grazing regimes. Extensive livestock grazing has a key role to play in managing fells. Absolute requirement for valued land management skills so crucial to maintaining the very fabric of the landscape and the right kind of habitat management. The fells can produce high quality sheep-meat - we need to market this better! Can we add more value?
What are the ecosystem services of particular local or national importance?	NFU	Clearly, farming, the cultural services provided by farming and the landscape, tourism and water provisioning are all key in these areas.
	SA	Clear from the PDF previously circulated.
	WCL	The uplands pretty much deliver the whole suite of ecosystem services, especially through the commons and open fell land
	Westcountry Rivers Trust	Biodiversity, Water Purification, Recreation and Culture (linked to traditional farming)

	RSPB	Abundant high quality raw water - a vital Lake District ecosystem service. The landscape, in part crafted by man over millennia, is the bedrock of a suite of cultural services, that drive the Lakeland economy. The fells also provide important regulating services - including carbon storage and regulating water flows.
How could the existing impacts of food production on delivery of environmental protection and enhancement be addressed and what impact this might have on food/crop production?	NFU	With no immediate prospect of increases to the HLS budget, farming in this area has to be profitable in order to help deliver additional environmental benefits. Private funding, in the way of payments for ecosystem services, may be an alternative source of funding for delivery of benefits for some.
	SA	Key is lower grazing pressure (less sheep) and more diverse grazing (more cattle). Leading to less but better quality and potentially higher value food production.
	WCL	There is a need for true recognition of the value of ecosystem service delivery which need to be costed fully and fairly - again relevant to the lowlands v upland benefits issue. Need for agreement on what the uplands are for. Need local consensus on the way forward and at a catchment or 'meaningful' scale - e.g. do we want our commons for rare plants, for cultural heritage, or water production? But is a

		particular species more important than the livelihood of a commoner?
	Westcountry Rivers Trust	I think this question is slightly leading and narrows the debate down to food production versus environmental protection, However, I think local spatial planning would permit the identification of areas more or less suitable for provision of one or multiple ecosystem services. Areas, which can be intensified for food production with little impact on other services, should be supported in this endeavor, intensification support should be conditional on the use of 'Smart Farming Methods' and Best Farming Practices which could be delivered through a simplified version of Cross Compliance linked to ELS (Currently we feel that much of cross compliance is not policed and enforced due to its high level of complexity). Areas which could produce food but are important for other services should be managed using traditional techniques and the lack of profitability of this approach should be offset by the incentive funding available e.g. HLS, Food QA, Visitor Bye-Back, Carbon Offset, Development Mitigation Funds, Green Taxes, PES Schemes with significant beneficiaries (SCAMP2) and whatever other incentives are available. To do this requires that the local spatial planning approach is community led, based on Ecosystem Service Provision rather than separate targeting statements for separate incentive funds focusing on a narrow array or even one Ecosystem Service. Policy needs to offer weight and credibility to locally derived spatial plans, which will enable development of local economic circuitry to support food production-profit forgone in favor of the provision of other ES's in certain areas. I have deliberately

		avoided being specific with farm measures which I think should be left to the authors of the local spatial plan. I think these local plans should accommodate national forcing functions such as the desired level of national food production and the high level predictions for land and climate suitability under climate change scenarios. A standard methodology for estimating the extent and weighting of ES provision across a landscape is required which also allows live scenario-testing to allow community involvement in planning and focusing incentive payments. In summary this is a shift to spatial planning for incentive payments based on Ecosystem Service Provision and with government support we feel this is eminently achievable.
	RSPB	This has been the source of some tension! Efforts to enhance the condition of designated sites has required significant reductions in livestock numbers. These reductions, supported by agri-environment measures (ESAs, Countryside Stewardship, Higher Level Scheme) have been contentious and divisive. Despite this, there is no doubt that in the absence of CAP support (both Single Payment and agri-environment), the impact of declining value of sheep-meat would have been very much greater. Whilst this remains a contentious issue in the Lake District, there are many positive signs that different sectors are trying to work more effectively together through a range of fora, partnerships etc. The development of the Lake District Management Plan supported by The Lakes Partnership (including a Farming and

		Land-use group) is one such example.
If food production were to increase in the case study areas (assuming continuation of current products/crops), what would be the likely impacts on various aspects of the environment?	NFU	I think this is a very difficult question to answer without having more information to hand about predicted increases. At best, we could only speculate.
	SA	It would instantly reverse the very modest gains made over the last ten years (which has seen a halting of rapid loss, as the paper notes), and halt and reverse the positive steps to start to reverse the damage done over the last 60 years (eg Wild Ennerdale, the potential positive impact of more use of HLS – both noted in the paper).
	WCL	What realistically, even if we went down the increased food production line would than mean for the uplands, bearing in mind they produce slow food? It's unlikely much contribution can be made to cereal production or increase the productivity of individual animals very much. All that could be done is go back to more livestock which would effect the delivery of other ecosystem services. Is anyone working on this?? The answer will depend on how much food production is increased and where. Inevitably

		there will be positive and negative impacts. Positive in that more food production may lead to better incomes for farmers with knock on effects for rural communities but also possibly land management and some ecosystem services - e.g. more money and more value in food - which may lead to more walls and boundaries repaired, etc as they have a more functional value again; this could also lead to more or increased cultural heritage value - more active commons mean more hefted flocks and traditions of communal grazing. Negatives would obviously be the impacts on ecology, and on water resources (more grazing leading to more erosion, leading to more soil and carbon loss and more colouration of water, etc). Again, it is the value of the food, not volume of the food that is key.
	Westcountry Rivers Trust	Without spatial planning I think you would see degradation in all other Ecosystem Services. Specifically Water Purification and Culture in the form of traditional farming techniques. Adopting smart farming approaches such as Zero Surplus Dairy Farming and Precision Farming would mitigate this to some extent but often requires investment and new non-traditional methods. Smart farming and spatial planning together might permit sustainable intensification but again will still require investment.
	RSPB	Firstly, it is worth noting that efforts to restore degraded habitats have required targeted (in places extensive) reductions in livestock. As elsewhere in the uplands, the increases in livestock numbers were largely driven by CAP headage payments. Livestock grazing continues to have a vital role to play. As

		habitats improve, more grazing animals may be required to maintain key habitats in good condition. This could mean that we see a modest increase in sheep (and hopefully cattle) numbers in future years. Efforts to increase livestock numbers more rapidly and ahead of improved habitat condition would halt the desired improvements in habitat condition, underpinned by agri-environment payments. Any further deterioration on fell and valley bottom (enclosed) habitats may also impact further on raw water quality and carbon stewardship. Clearly, with improving market conditions and a changing climate, it may be possible to cultivate lowland soils, that are currently under pasture. Whilst a degree of mixed cropping may be valuable (e.g. for biodiversity), the loss of enclosed pasture may impact on how stock is managed on unenclosed land. A concerted effort to add real value to fell-bred lamb/mutton may make more sense and would build on excellent work already underway in the NW
What would long term reconciliation of ecosystem services (food provisioning, biodiversity, water quality, carbon	*NFU*	Agriculture is critical to maintain the special landscapes that are valued. In addition, I think we can learn from the analysis undertaken by North York Moors National Park in its draft management plan http://www.northyorkmoors.org.uk/uploads/publication/12228.pdf where it looks at reconciling how

storage etc) look like		we can produce more food in the North York Moors while also maintaining the special qualities of the Park.
	SA	The need for the changes noted above – typical of the changes needed in most upland areas
	Defra science team	How sustainable intensification and a better environment could be achieved in the uplands In lowland areas there are some obvious win/wins around increased resource efficiency that are already leading to improvements in water quality. The conservation of farmland biodiversity can also be accommodated, to some degree by the use of the least productive land for intensive conservation management, an approach known as 'land sparing'. In upland areas, where the whole farmed area is of high biodiversity value and important for the safeguarding of other ecosystem services a 'land sharing' approach is needed, but UK experience to date has been that increased agricultural production in the uplands is almost inevitably associated with losses to a variety of other ecosystem services. The solution may lie in developing markets for some of these other ecosystem services in order to provide alternative income streams, but there is a very long way to go. There have been a few attempts to combine intensification and environmental benefits in other countries (e.g. Anon 2008), but it remains to be seen whether this experience could be directly transferred to this country.
	WCL	To answer this question requires analysis and research into what is technically/realistically

		possible. Perhaps as mentioned previously it would be better to go for value/quality and not volume. There has been a strong focus on trees and peat bogs for carbon storage, but the factual data shows that untilled soils in the uplands store the greatest amount of carbon. This is a major market advantage over lowlands and ties in with the point about extensive 'slow' protein in the uplands. Current livestock farming systems cannot be profitable on their own and deliver water quality, public access, biodiversity etc. Need diversified off farm income (or visitor spending on the farm cottage etc.), plus an area payment for sustainable land cover which delivers the full compliment of ecosystem services
	Westcountry Rivers Trust	In this instance I think that intensive farming will need to be focused into the most suitable areas and elsewhere, cultural un intensive farming will need economic support to be competitive. Just as the funding for intensive food production will come from the food market, the funding for the de-intensified areas needs to come from the beneficiaries of the wider ecosystem services arising. Water Purification is a significant alternative ES and so a strong PES mechanism does and should continue to exist. Other important ES's include Biodiversity, Tourism and Culture and these sectors need to contribute to the cost of incentivizing de-intensification in targeted areas. A viable visitor payback Scheme already exists in the area and could be extended and linked to the local spatial plan. We feel that this needs some form of government sanction and encouragement to

		make it an official visitor payback scheme which links to the plan. Culture and Biodiversity are difficult to monetize in any simple way and so market creation for the services is difficult to envisage, however Tourism relies strongly on these two ES's and will provide some funds in addition to national funds for Biodiversity and Culture from RDPE/CAP. Uptake of the incentives would be voluntary but we do not feel this limits the potential delivery provided trusted local advisors are used to develop the transaction between farmer and ES market.
	RSPB	In reality, this depends on the absolute mix of ES demanded/delivered in any particular part of an area. One thing is clear - reconciliation demands that we develop more accountable and democratic decision making bodies that recognise the roles and responsibilities of those who produce/secure the delivery of vital ES and also the beneficiaries of these same ecosystem services. Given what we know about predicted climate change and the vital nature and vulnerability of the uplands, it is probably fair to say that the uplands of the future may look quite different. Putting more woodland back, where it has been lost over generations, and securing wetlands and carbon-rich soils are vital. The development of landscape approaches, led by locally accountable bodies, with input from the key beneficiaries, may help develop a shared sense of purpose and help further recognise/cement the vital role that land

		managers need to play now and in the future.
Other comments	*NFU*	I wasn't too sure of the value of the generic information from the NEA on 'Mountain, Moor and Heaths'. This does not appear to be regionally specific. I commented on a number of the NEA chapters while they were still in draft and I had a concern that the Mountain, Moor and Heaths one didn't really consider the value of farming to these landscapes. Essentially, if you do not have viable farms you cannot sustain the other services that these landscapes provide.
	NFU	We are unsure of the usefulness of the references to 'reducing intensity of sheep production' in the Lakes for the above reasons. Farms need to remain viable.
	NFU	The data provided on deer and grouse management is not particularly relevant for the Lakes, although may be more relevant for the north Pennines.
	WCL	Responses to questions are different for in-bye land v fell land – we have focused on the latter in our answers

Tamar case study

Question	Organisation	Response
What are the current tensions and synergies between current	RSPB	Large areas of the Tamar catchment are intensively-managed grassland, with a low proportion of semi-natural habitat (see Figure 2 – BAP habitats) and little arable/ mixed farming.

food/crop production and delivery of environmental protection and enhancement objectives?		Between 2000 and 2008, the area of permanent grassland increased by 14% but temporary grass and rough grazing decreased by 7% and 23% respectively. This homogenous landscape is not favourable to farmland biodiversity – although there are still areas of biodiversity interest (see HLS targeting statements). The impact of land use on the water environment (both river and coastal) is a major issue in this area. The majority of the catchment is classified as 'at risk' or 'probably at risk' from diffuse pollution (Figure x – WFD classification). Current ecological status of most rivers is 'moderate' or 'good', with a 'poor' section at the northern end of the catchment.
What are the ecosystem services of particular local or national importance?	NFU	Agriculture is certainly of particular local importance. The landscape is pastoral and with the levels of rainfall seen in this area, a pastoral agricultural system is likely to continue. Water provisioning has also been identified as another important service. The moors are particularly important in providing water.
	RSPB	Livestock that are grazed in summer on Dartmoor and Bodmin are often brought down to the lowlands for winter. Therefore the intensive grazing in the river valley is part of a wider farming system which can deliver benefits in the uplands. Tourism/ recreation: The lower Tamar valley is

		an AONB. The AONB includes intertidal zones in the Tamar estuary, which supports wintering waders and wildfowl and is designated as a Special Protection Area. The AONB also has a significant industrial heritage. The dominant landscape structure across much of the AONB results from medieval and post-medieval enclosures. This unspoilt pattern of settlement, lanes, fields, woodland and hedgebanks, in tandem with a precious collection of well-preserved medieval bridges, is an outstanding landscape legacy. The AONB is an established recreation destination for both Plymouth residents and tourists from further afield. Recent work by South West Tourism and others has concluded that 85% of visits to the South West are motivated by protected landscapes. With trends suggesting that heritage and rural tourism are set to expand, there will almost certainly be a growth in tourism and recreation in the Valley.
How could the existing impacts of food production on delivery of environmental protection and enhancement be addressed and what impact this might have on food/crop production?	NFU	For areas in an NVZ, increased costs of meeting the requirements is certainly a threat to many smaller dairy farms in the area. An adequate grant scheme, and other incentives and encouragement (see question 4 below) would help meet the costs of the NVZ requirements. This could allow continuation of the smaller dairy farms in this area. Lack of a grant scheme in NVZ areas is a key issue in this area. However, a potential synergy in this area and others is Environmental Stewardship – allowing farmers to produce food and protect the environment at the same time. A more smooth join-up between Catchment Sensitive

		Farming and agri-environment schemes would also be helpful. Upstream Thinking, the SW Water initiative exists in this area and supports farmers by providing funds to reduce diffuse pollution and improve water quality. They provide part funds for slurry storage – very valuable where these funds don't exist elsewhere. And they also work closely with the Westcountry Rivers Trust – a known and trusted intermediary in the SW, who liaise with farmers on their behalf.
	RSPB	Various measures could be taken to restore higher levels of biodiversity to the landscape. These range from easy measures that can be incorporated into existing grassland management, for example allowing small areas of grass to go to seed to provide food for birds, or leaving winter stubble across 1% of the landscape, to more radical changes such as a move back to mixed farming or horticulture (also cross-reference with the environmental paper produced for the Dairy GFP group). The upper end of the Tamar is in an area called the Culm and the grassland here is of high biodiversity, mainly plants and Lepidoptera (especially Marsh Fritillary), but bird interest includes willow tit, grasshopper warbler, cuckoo etc. Restoration of this grassland would be a priority and will provide huge ecosystem services downstream.
	Defra	ECSFDI has a capital grants scheme to help

	science team	support a reduction in diffuse water pollution/improve water quality. There is a debate over whether farmers and land managers should be incentized not to pollute or if the polluter pays principle should be applied. Potential improvement to grassland management includes the use of legumes and greater diversity of grass species in swards, rather than monoculture ryegrass. What is the evidence that horticulture would provide more environmental benefits than grassland?
If food production were to increase in the case study areas (assuming continuation of current products/crops), what would be the likely impacts on various aspects of the environment?	NFU	This is a very difficult question to answer without having more information to hand about predicted increases. At best, we could only speculate.
What would long term reconciliation of ecosystem services (food provisioning, biodiversity, water quality, carbon	NFU	As we have indicated, agriculture and particularly pastoral agricultural systems are likely to continue to dominate in this area. A more efficient agriculture would co-exist with the environment, but with additional private funding, such as water company funding, we could see improvements in biodiversity and

storage etc) look like?		water quality. Further points:
	RSPB	Currently the focus is heavily on one particular form of food production (namely livestock farming), which has come at the expense of biodiversity. A better balance would involve restoration of biodiversity. The nearby Cirl Bunting project gives an example of a possible restoration 'pathway'
	Defra science team	Should we talk about optimisation instead of reconciliation? In which case, we need to know the values of the ecosystem services and look at the cost-benefit ratios of different strategies. We probably need both 'land sparing' and 'land sharing' approaches for this area. i.e. looking at ways of enhancing biodiversity in field (e.g. through more diverse swards) and devoting some land specifically for biodiversity, landscape features, access, etc (e.g. ecological focus areas). Developing 'land sparing' approaches to intensive grasslands took longer than for arable areas, but much of the necessary underpinning research has now been done (See for example Buckingham et al. 2011, Peach et al. 2007 and Pywell et al. 2007). For species rich grasslands, we have a fairly good grasp of the impact of soil pH, nutrient status, fertilisers and manures on species-rich grassland (Kirkham et al, in prep) and the

		management needed to restore and re-create most types of species-rich grassland, though this knowledge has served to highlight how difficult this management can often be to achieve in practice.
Other comments	NFU	Much of the data provides a snapshot in time but very little general trend data is provided. If we had trend data that would help us establish whether we are going / headed in the right direction on some of the issues highlighted.

General comments/ applied to all three case studies

What would long term reconciliation of ecosystem services (food provisioning, biodiversity, water quality, carbon storage etc) look like?	*NFU*	• **Increased production efficiencies.** There are potential benefits in increased production efficiencies. Furthermore, the farming sector in England has launched its own Greenhouse Gas Action Plan setting out how the industry will reduce its greenhouse gas emissions. It shows a commitment to playing our part in tackling climate change by reducing our emissions by three million tonnes of CO_2 equivalents per year from 2018-2022. For example, the EBLEX Change in the Air shows how the beef (and sheep) sector intend to contribute, through production efficiencies, to this 11 % reduction. This will include better breeding and improved feed efficiencies. The DairyCo Dairy Roadmap will help the dairy sector contribute to this 11 % reduction. • **Planning policy has to enable on-farm development.** The NPPF goes some way towards this but we feel there needs to be a stronger recognition of the importance of food production and renewable energy. • **A transformation in farming techniques is needed. For this, applied research and**

		knowledge transfer will be critical. We need to better understand and better manage the interactions between the impacts of climate change, our use of natural resources, wildlife and food production. Key elements in this are an efficient use of nutrients, feed, water, pesticides, energy or light by the plant or animal; using technology and machinery to increase efficiency and target inputs; and reducing waste from the system. And critically, for this to work on a commercial scale we need to have an effective knowledge exchange with farmers, identifiable networks of experts and research centres, and good demonstration facilities. • **Technologies and new approaches to help meet the challenge of "sustainable intensification" are also important.** This includes precision farming, genetic improvement of both crops and livestock (including GM methods). It can help improve the efficiency of farm operations including cultivations and better targeted fertiliser and agrochemical applications. Targeting just those plants or areas of land that are in need improves yield without losses to the environment. • **Delivery of the right advice is also key.** We need to build on the success of initiatives such as the Campaign for the Farmed Environment. Key to the success of this voluntary management approach is the role of local delivery groups in some 22 counties in England and known and trusted agricultural advisers such as agronomists. • **Investment on farms is also essential.** There are numerous examples of smart investment that offer a platform for renewable energy, machinery that is 'smarter' using GPS to be more precise in the use of precious inputs, or capturing manures and slurries to use better for nutrients and energy. All of these require farmers to scale up investment. It goes

		without saying that market conditions that ensure farmers have fair and profitable returns are central to this. But government can ensure that we have a tax system that incentivises farmers to invest – enhancing capital allowances or grants, could be part of the mix of measures. Secondly the way the Common Agricultural Policy is deployed, notably in terms of rural development programmes is a factor. And thirdly, there is a planning framework.
	Defra science team	The current debate about sustainable intensification is largely framed around the assumption that the current paradigm of low labour but capital and energy intensive agriculture will continue. It is worth considering whether the combination of multiple, conflicting demands on land management, increasing commodity prices and possible future scarcities (e.g. phosphates), combined with climate change, may force a 'paradigm shift' in agricultural systems. If it did, would this solve the problem of reconciling increased production and environmental conservation, or simply raise a whole set of new issues?
General	*NFU*	Much of the data provides a snapshot in time but very little general trend data is provided. If we had trend data that would help us establish whether we are going / headed in the right direction on some of the issues highlighted.
	Westcountry Rivers Trust	• The main point is that I/we would like to see the alignment of incentive funds in order to deliver de-intensification according to a catchment scale plan based on weighted Ecosystem Service Delivery. I hope the Tamar Pilot Project will produce a transferable scalable method for this planning process. The intention is then to roll out the catchment planning process across England.

		• Sustainable Food Production can only be delivered in catchments which also accommodate the delivery of the wider needs of society and internalize the costs of this delivery as much as is possible nationally. • Finally, where food is produced 'at full tilt' in the most suitable areas, funded primarily by the food markets, we feel that Cross Compliance could be simpler and designed to be easier to assess and regulate. We feel that some transitional funding for slurry storage or smart farming training and tools would be required in the short term and in the longer-term reinvestment in the business could be incentivized, perhaps through taxation. We also feel there is a need for and the provision of a long-term, stable, non-regulatory, local, not for profit extension service to link famers to the catchment plan and help set up the whole farm package of delivery.

Annex N1: Norfolk farm scale case studies

Case study 1: Courtyard Farm

Type of farm: 360ha, mixed, organic

Famer: Lord Peter Melchett

Location: near Hunstanton, Norfolk

Current management

Courtyard Farm was purchased by Julian Melchett in 1959, and converted by his son, Peter Melchett to organic between 1998 and 2000. The farm area is 360 ha, with 150 ha combinable crops, 90 ha grassland and 17 ha woodland. The holding has fairly uniform light, sandy soils over chalk and flint. The current arable rotation is 2 years red or white clover, Spring wheat, Spring barley, fodder peas, Spring wheat (undersown with clover), plus some vetch. All arable crops, vetch and white clover are grown on contract for seed. Red clover is cut for silage. The farm has a herd of Norfolk Red Poll cattle and around 30 breeding sows and young in outdoor pens. Cattle are sold for breeding and as stores, pigs sold locally to an organic farm shop, local butcher and local pub, and some to an organic pork processor.

Clover is used for fixing Nitrogen without using artificial fertiliser. After growing under a wheat crop for one year, the clover remains undisturbed for two more years, to maximise Nitrogen fixing, and cutting down on ploughing. The clover fields are either harvested for clover and grass seed or cut for silage (to feed the cattle in winter), and used to house the pigs on, and grazed by young cattle in summer. Manure from cattle housed over –winter also adds some fertility to the soil, mainly in form of Phosphorus and Potassium. Four spring-sown arable crops are grown before returning to clover.

In most years, pea, barley and wheat yields are around 3.7 tonnes per hectare. Vetch is a new crop, but estimated yields to date are around 2.5 tonnes per hectare. The

crops grown for seed attract a premium price, for example for wheat and barley a premium of £20-£25 per tonne over organic feed price is received.

Courtyard Farm employs 2 full-time staff, and with regular part-time workers this provides the equivalent of three full-time jobs.

Public access and education

Public access is encouraged: there is designated car-parking, two 2 mile way-marked circular walks and one 6 mile walk around the farm on public footpaths, as well as several miles of permissive paths. Free farm leaflets are available and there are notices showing walks and giving information about woodland and pond management. The farm also has a website at www.courtyardfarm.co.uk.

The farm has a bunkhouse barn, popular with holidaymakers. Major selling points are that the farm is organic, the extensive walks and rides, wild flowers, and wildlife. All the original farm buildings have been preserved – apart from the bunkhouse, the two barns are in agricultural use, the previous fertiliser shed is used by a local fisherman and by a carpenter.

An education programme with a local primary school has run for many years and there are many other visiting groups including farmers, policy makers and students.

Biodiversity

The holding encompasses a range of habitats including chalk grassland, coastal flood plain grazing marsh, field margins, scrub of high environmental value, mixed and deciduous woodland. There are also significant breeding and wintering bird records for the holding including good populations of declining farmland birds.

Habitats are managed through an OELS/ HLS agreement, with the following aims (in addition to managing historic features – see below):

- manage the wet grassland for breeding waders.
- maintain areas of chalk grassland (BAP habitat) by continuing grazing and scrub control.
- maintain lapwing and brown hare (BAP priority species) through sensitive management of existing grassland and arable habitats.
- create and enhance habitats for grey partridge, turtle dove, corn bunting and tree sparrow and Spring/autumn germinating arable plants with floristically enhanced grass margins, cultivated plots, maintaining scrub and other arable options.
- create recreational opportunities for the public by opening footpaths around the holding.

Figures 1 and 2 show the HLS options in place. OELS options consist of enhanced hedgerow management, over wintered stubbles and under sown spring cereals.

As an organic farm, the focus is on building up healthy soil to benefit insects and native plants which, in turn, attracts birds and mammals. Hedges and woodland encourage natural predators like ladybirds and lacewings, and provide shelter for livestock. Over winter, fields of grass, clover and winter cover crops help to retain nutrients in the soil and support overwintering wildlife. Wheat and seed is provided in feeders for birds in the winter, and under the HLS agreement two small areas of wheat and other seed crops are left unharvested each year, to provide winter feed.

Since 1959, many actions have been taken to enhance the holding's biodiversity value. Marl pits have been maintained and planted with native trees; six small new woods have been planted and older woodlands are actively managed; one pond has been restored and four ponds created. Year-round bird feeding is carried out and large numbers of nest boxes have been erected. The nest boxes were surveyed in 2011 and 70% of them found to be occupied. Over 40 hectares of arable land (initially set aside, then Countryside Stewardship, now in HLS) was planted as flower rich chalk grassland and is now managed by cutting for hayledge one year, summer grazing the next. Japanese privet hedges have been replaced with native hedges; several newer hedges laid; and there has been extensive planting of new native species hedges. Holme Marsh SSSI is managed jointly with the Norfolk Naturalists' Trust, creating new reedbeds and open water.

Extensive monitoring of farmland birds and other wildlife is carried out. Detailed moth records were kept between 1998 – 2001, over which period 265 species were recorded. Grey partridge records are available back to 1926 (Figure 3). This long-term data set reflects the national decline in partridge numbers over the 1960s and 1970s (see for example the Game and Wildlife Conservation Trust partridge count scheme). Grey Partridges on Courthouse Farm reached a low of 16 birds in the Spring during the 1980s. There was some recovery around the time the farm converted to organic, and numbers of partridge have now stabilised at around 40 birds. 12 of the 19 species making up the UK Farmland Bird Index were recorded as breeding regularly at Courtyard Farm between 2006 - 2010. The Norfolk Bird and Mammal report 2010, produced by the Norfolk and Norwich Naturalists' Society, suggests that a number of these farmland bird species are faring better, or at least as well as elsewhere in the UK, although the sample sizes for some species are too small to attach statistical significance to them.

Historical features and landscape

The holding is an excellent example of an enclosed planned landscape resulting from enclosure in the 18th-20th centuries. There are two distinct areas comprising 18-19th century enclosure, 19-20th century drained enclosure and reclamation, and 20th century agriculture. The holding includes 20 hectares of Ringstead Common, a fuel allotment set aside on enclosure, and mainly reclaimed for arable during World War 2. The survival of what is left of Ringstead Common is an extremely important aspect of the holding.

The fields were generally enclosed in 8-14 hectare blocks, and apart from four small paddocks near the farm buildings, and one field division, no hedges have been removed since 1780. Two shelter belts were planted in 1780/1800. The main farm buildings were built when the land was enclosed. The buildings of Courtyard Farm are of particular note being rare in design and in very good condition.

The farm is in the North West Norfolk National Character Area and exemplifies many features of this landscape:

- Big skies and extensive views, exposed
- Open, large-scale, rounded rolling hills and plateaux
- Large belts of mixed woodland
- Large, regular late Parliamentary hedged enclosures
- Remnants of unimproved grassland
- Georgian farmhouses, claytiled and flint

Carbon

Data on soil organic matter across the farm (light, chalk and sand soils) shows a steady increase from 2001 to the present. Holme Marsh (clay soils) has a significantly higher soil content than either the arable or grazing land. A full Life Cycle Assessment of the farm's greenhouse gas footprint is currently being carried out by experts at Manchester University.

Reconciling food production and environmental objectives

Farming organically allows the farm to produce a premium product while supporting significantly increased wildlife. In putting some of the land into semi-permanent wildflower meadows in HLS, the farmer has made a decision to prioritise the environment and wildlife on those areas, but all of them are grazed by the herd of beef cattle and produce hayledge, and therefore contribute to food production as well as biodiversity and, most significantly, soil carbon sequestration. Other than food production, the farm provides a range of ecosystem services. Farmland wildlife has

always been a priority, and latterly the contribution the farm can make to sequestering soil carbon by increased Soil Organic Matter has come to the fore. Contributions to cultural ecosystem services in the form of public walks and attractive scenery are a significant outcome of how the farm is run.

Having previously farmed conventionally for nearly 40 years, Peter feels strongly that converting to organic has largely removed tensions between food production and the environment on Courtyard Farm. He believes that the farm's production and environmental performance could be enhanced further in future with the application of new knowledge. This is being held back by a lack of agricultural research aimed at providing public goods and enhancing biodiversity within organic farming systems, and in particular at increasing agricultural yields from organic farming.

It would hypothetically be possible to increase food production on Courtyard Farm by substantially increasing resource use, for example by introducing irrigation using ground water or increasing nutrient inputs by using mined phosphates and fossil fuel-based manufactured Nitrogen. This would increase yield in tonnes per hectare, but would not necessarily increase production in terms of yield per tonne of input per hectare. An increase in nutrient inputs would lead to an increase in crop diseases and damage by insect pests, and would require the use of a wide range of pesticides. The result would be high levels of non-renewable resource use (particularly fossil fuels and mined phosphates and water), lower levels of farmland wildlife, and significant increases in diffuse pollution.

There are no plans to radically alter the way the farm is managed to balance food production and environmental objectives in future. In years to come, fixing nitrogen through legumes will become progressively more cost effective compared to extracting nitrogen from the air using fossil fuels or other expensive sources of energy, so the farm is likely to produce food that is increasingly comparatively cheaper than non-organic alternatives.

Acknowledgements

The information presented here is taken from the OELS/ HLS agreement for this holding (kindly provided by Natural England), the Norfolk Bird and Mammal report 2010, and from data held by the land owner, Lord Peter Melchett. The opinions expressed are those of Lord Melchett. All information is made available with the kind permission of Lord Melchett.

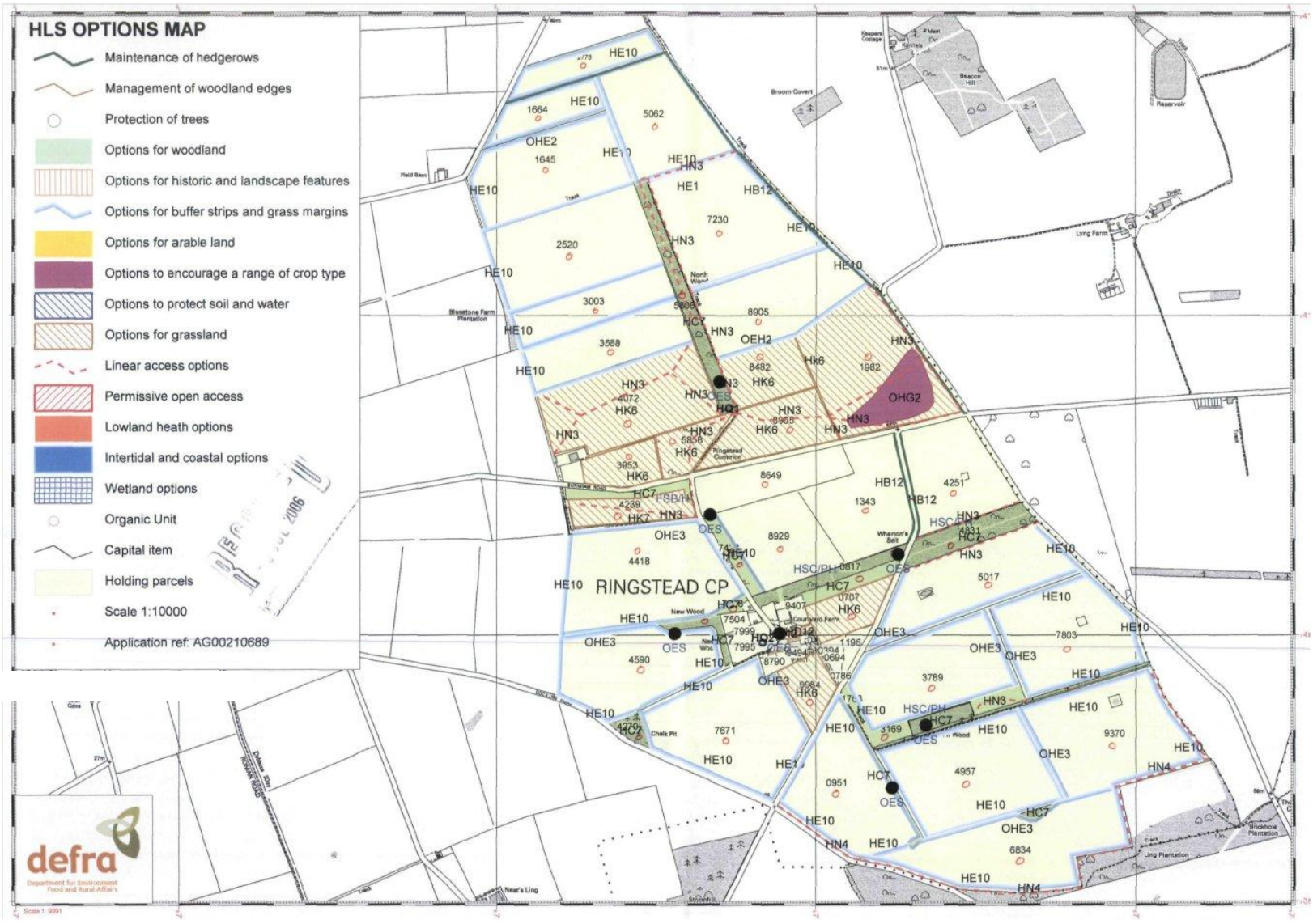


Figure 2: Higher Level Stewardship options

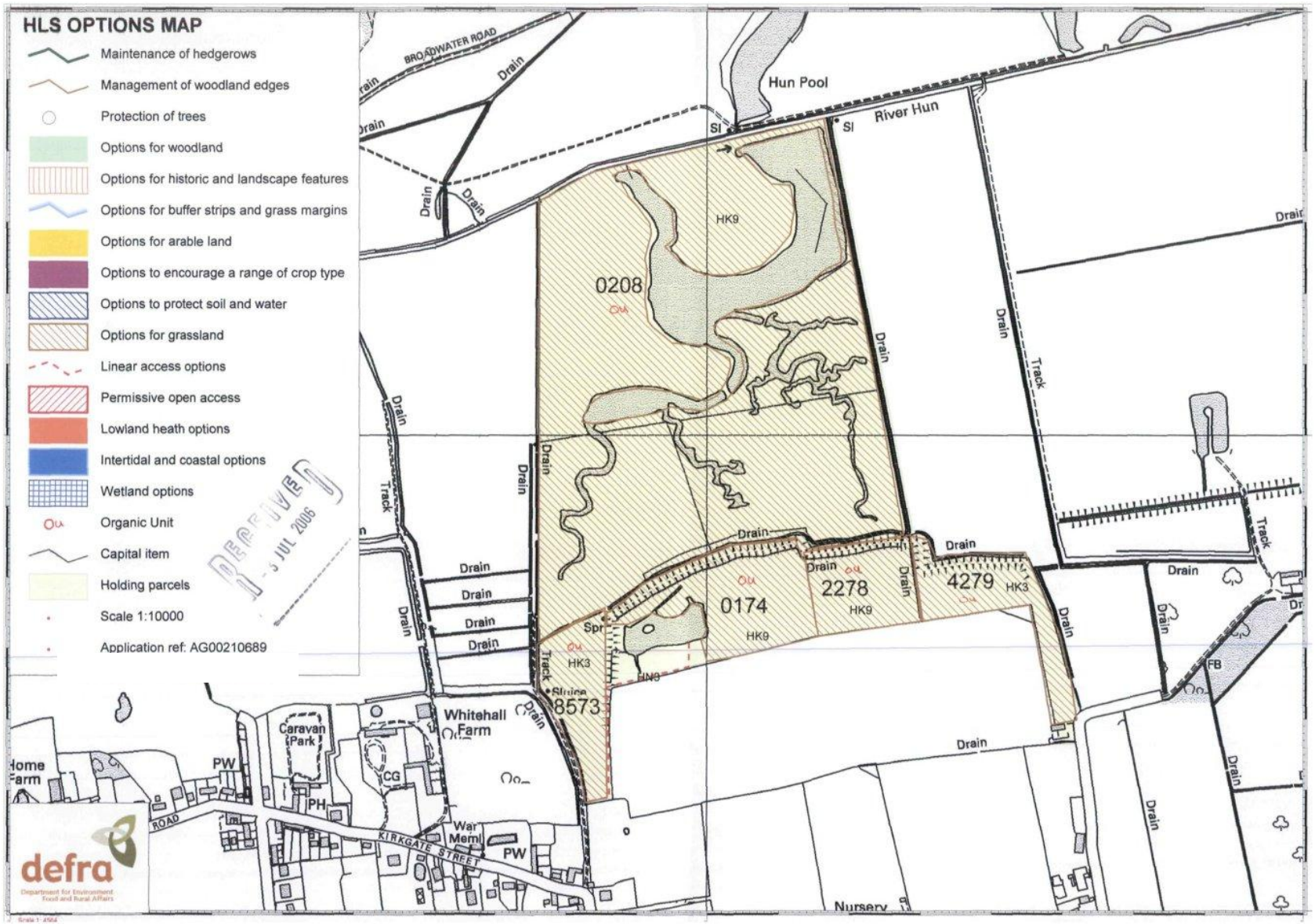


Figure 3: Higher Level Stewardship options

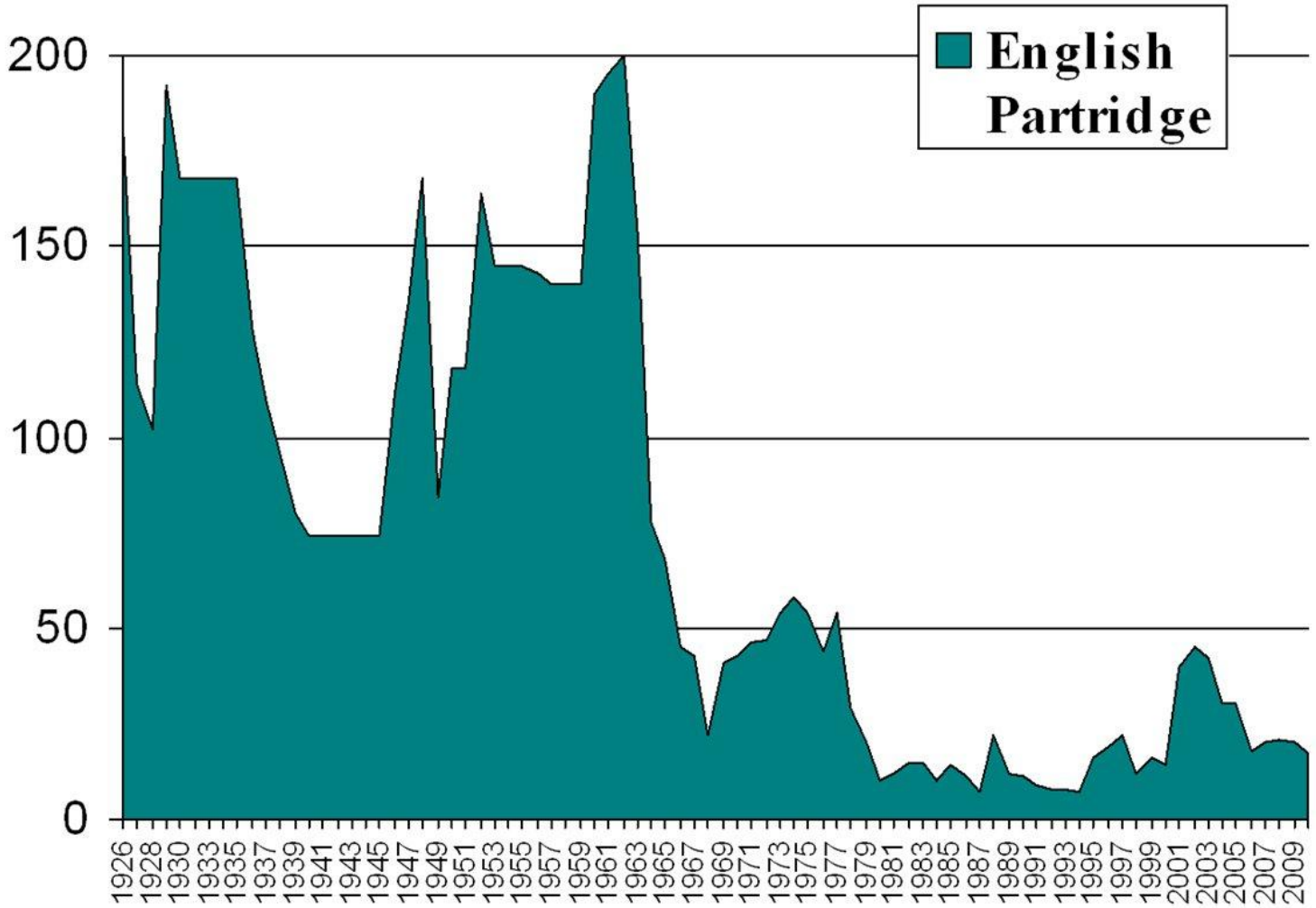


Figure 4: summary of spring partridge count: number of pairs counted 1926 – 2010

Case study 2: Copys Green Farm

Type of farm: 230 hectares, dairy and arable

Farmer: Dr Stephen Temple

Location: Wighton, Norfolk

Current management

The farm was started in 1912 by the current owner's great-grandfather, with 14 hectares. The holding is now 230 hectares in total. The majority of the land is owned, with 9ha of meadows rented from Holkham Estate. The main enterprise is dairy, with approximately 100 cows and a similar number of young stock. Cropping is 65ha grass, 162 arable.

The dairy herd is predominately pedigree Holsteins, with some Brown Swiss. The cows are fed on maize and grass silage, topped up with concentrate. They are milked twice a day, and the average milk production is 10,500 litres a year.

Crops grown are spring barley (for seed) and winter barley, spring beans, fodder beet and silage maize. There are 45.7 ha of grass and clover ley, plus 24.5 ha of permanent pasture and 3 ha of buffer strip grass. 7 ha are let for strawberries.

A quarter of the milk produced on the farm is used for cheesemaking, with the rest sold wholesale. The farm has its own cheese brand, Mrs Temple's Cheese, offering a variety of handmade Norfolk cheeses. The cheese is sold through local farmers markets, delicatessens and hostelries. This enterprise employs three people.

Other enterprises on the farm include contract work and farm electronics. In addition to family inputs and the cheese staff, the farm employs 6 dairy and arable staff (5 full time and 1 part time) and a part-time farm secretary.

Minimising greenhouse gas emissions

The farm selects equipment on the basis of energy efficiency, and uses carbon-neutral fuel wherever possible. The farm has an anaerobic digester producing heat and power. It is fed around 7 tonnes slurry, 7 tonnes maize silage or fodder beet plus whey from cheesemaking every day. The gas is used in a combined heat and power unit, producing

up to 170kW of electricity for the grid and the farm's own use. The heat is used to maintain the digester temperature, heat the house, make cheese, dry crops, heat the dairy wash water and supply warm drinking water to the cows. The digestate is separated into solid and liquid components, and the solid component is spread on fields to recycle the nutrients, greatly reducing the need for bought-in manufactured fertiliser. Other benefits from the anaerobic digester are reduced odour, reduced potential for diffuse pollution, and containment of manure meaning that methane emissions are minimised.

In addition, strip tillage for maize is being trialled. Strip tillage has the effect of reducing energy requirements for maize establishment and reducing the potential for soil erosion by wind and water, as well as conserving moisture. This has only been possible since the anaerobic digester was installed, as the digestate does not need to be ploughed under, unlike farmyard manure.

In recognition of the Temple family's achievements in sustainable energy, the farm has won several awards including the Royal Association of British Dairy Farmers Energy Efficiency Award in 2009, and the Farmers Weekly Green Energy Farmer of the Year in 2010.

Reconciling food production and environmental objectives

For Copys Green Farm, environmental objectives start at the large scale, in terms of energy use and generation. Energy use is assessed and minimised, and low carbon energy is used wherever possible. In addition, as much as possible of the livestock diets are grown on the farm, reducing haulage distances and fuel use. The cheese produced by the farm is therefore a good example of a sustainable food product: made using renewable energy, with milk produced using as much farm-grown feed as possible. Copys Green Farm provides an example for other farmers of what can be achieved in sustainable energy. This is reflected in its success in winning the Royal Agricultural Society of England's 'Excellence in Practical Farming and Business Award' 2011 – this recognises those who are setting a lead for other farmers.

Stephen feels that there is little point in micro-management of wildlife and habitats if global warming is going to wipe out the lot, which is why efforts are primarily involved in reduction of greenhouse gas emissions. Nevertheless, the way the farm is managed delivers many benefits for biodiversity. The anaerobic digester removes the majority of the polluting Biological Oxygen Demand (BOD) from the dairy slurry, particularly important given that the farm is close to a sensitive chalk river, the Stiffkey. Although Copys Green Farm is not currently signed up to an Environmental Stewardship agreement (this was not feasible during the recent reorganisation of the farm), several environmentally-beneficial management options are already followed. Grassed buffer strips are maintained alongside watercourses and the 'no-spread zones' are wider than the minimum legal requirement. The strip-tillage method adopted for the maize crop involves over-wintering stubble (albeit with some weed control), of benefit to many farmland birds. Forward planning for crops is constrained by the needs of the dairy herd and the anaerobic digester, but future

aspirations include incorporating a small area of lucerne into the rotation. Stephen intends to enter the farm into Environmental Stewardship in the future, but is currently waiting to see the outcome of the Common Agricultural Policy reform proposals.

The key to reconciling food production and environmental objectives, beyond addressing greenhouse gas emissions, is tailoring land management to local conditions. By selecting fields for the most appropriate functions (grazing, arable) in terms of proximity to water courses, slopes etc., it is possible to optimise food production without compromising the environment.

Acknowledgements

All information presented here is made available with the kind permission of Dr Stephen Temple, a Director of Copys Green Farm. The opinions expressed are those of Dr Temple.

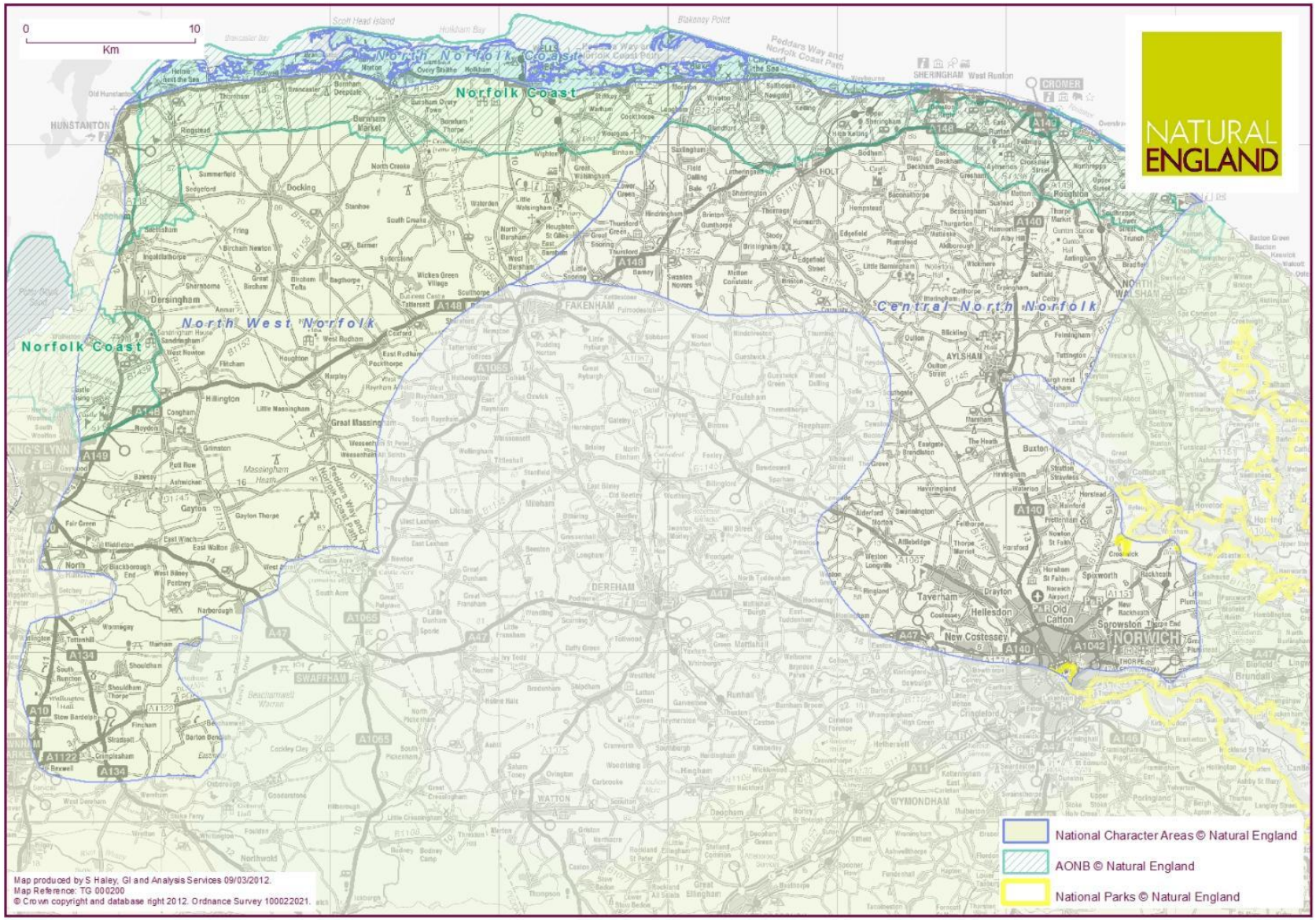


Figure N1: National Character Areas and landscape designations

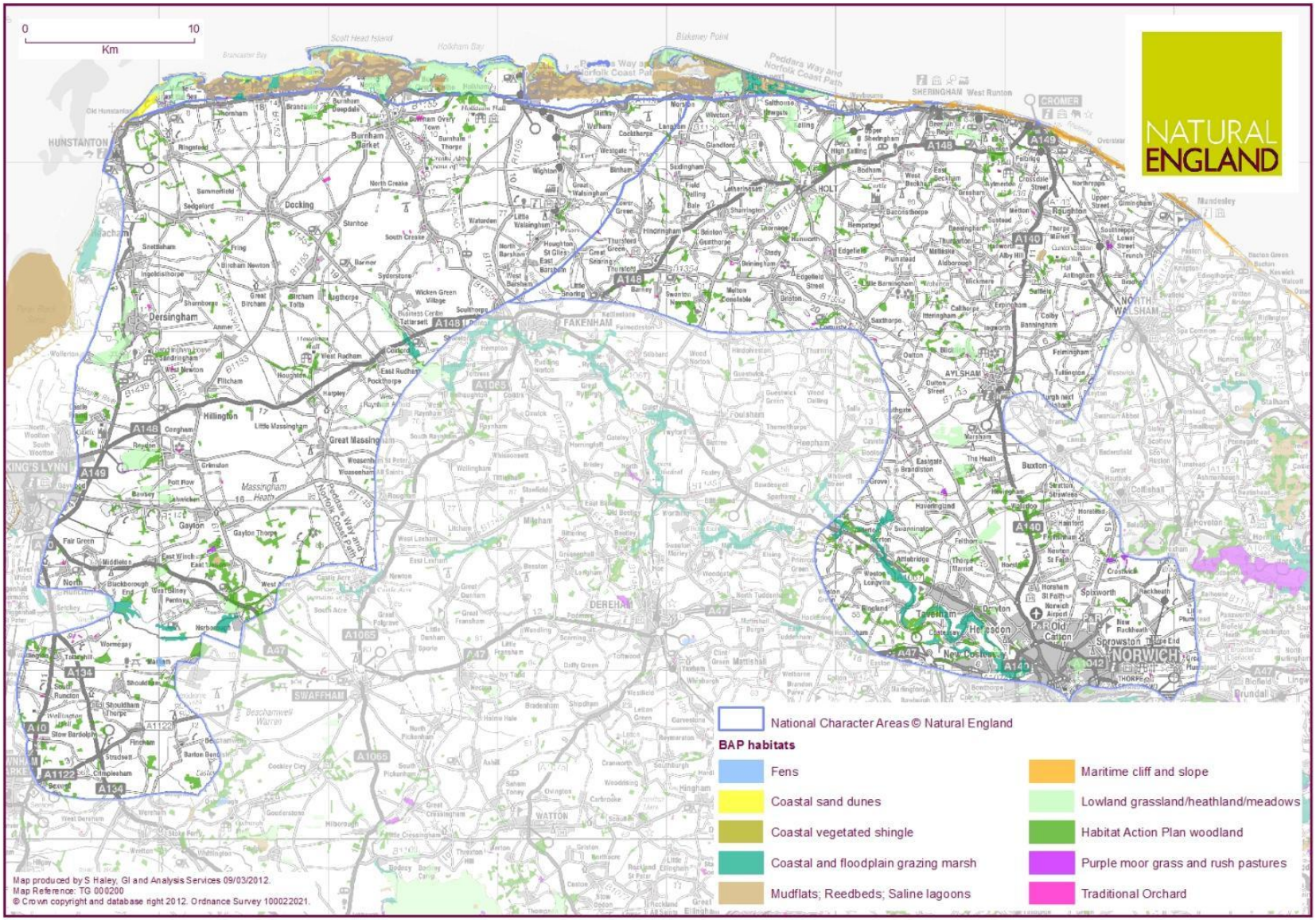


Figure N2: Biodiversity Action Plan habitats

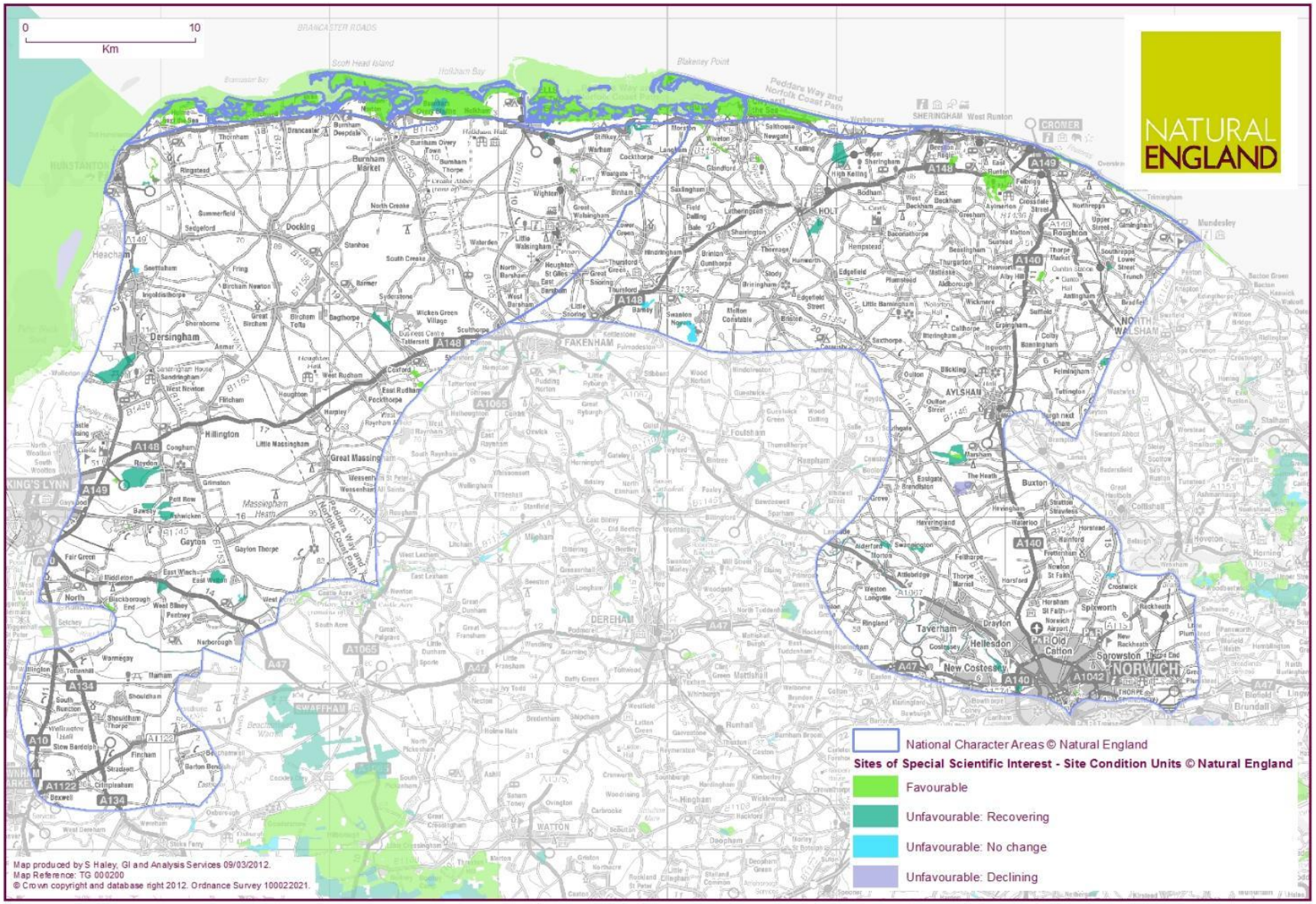


Figure N3: Location and condition of SSSIs

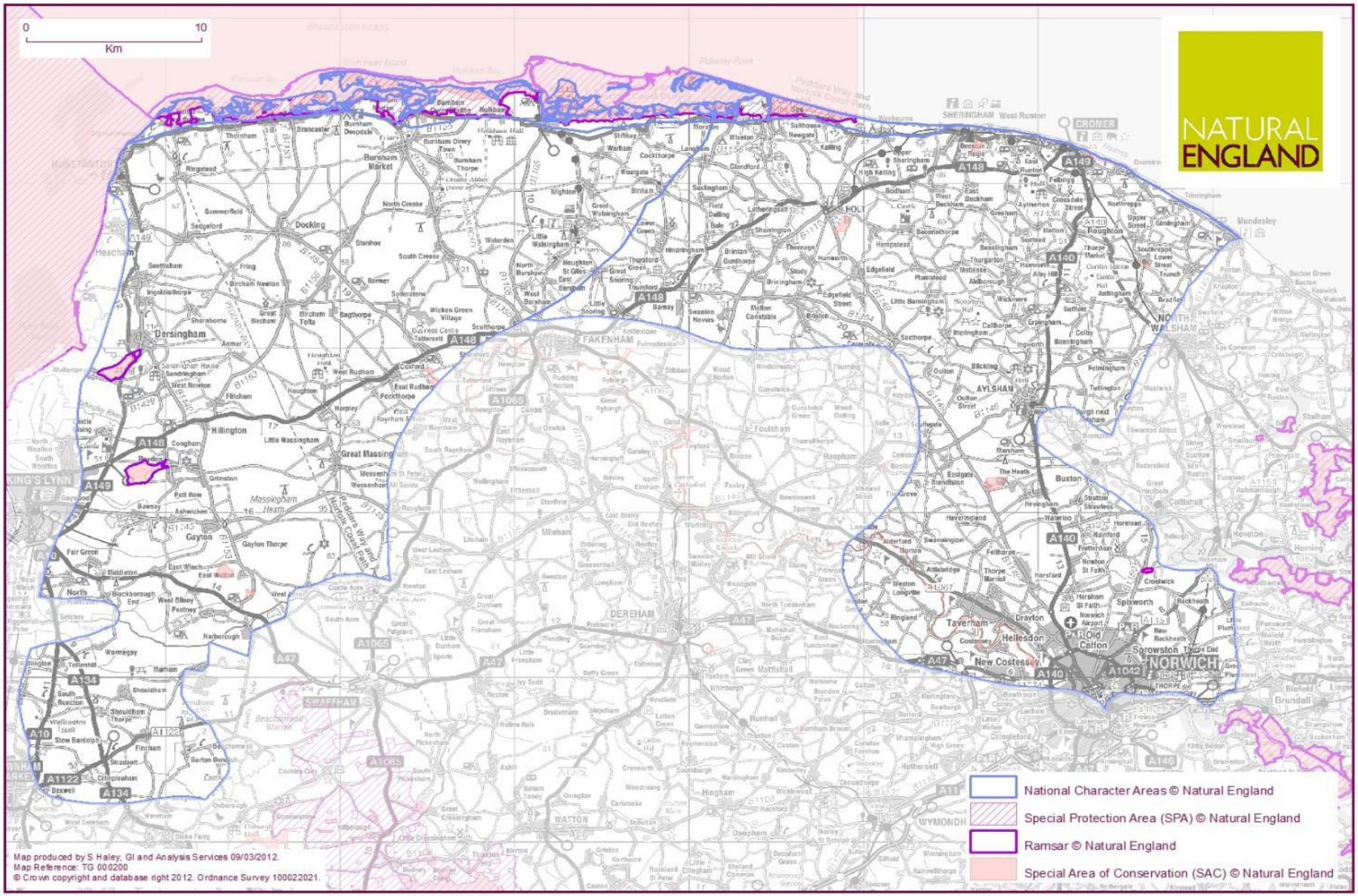


Figure N4: Statutory designations

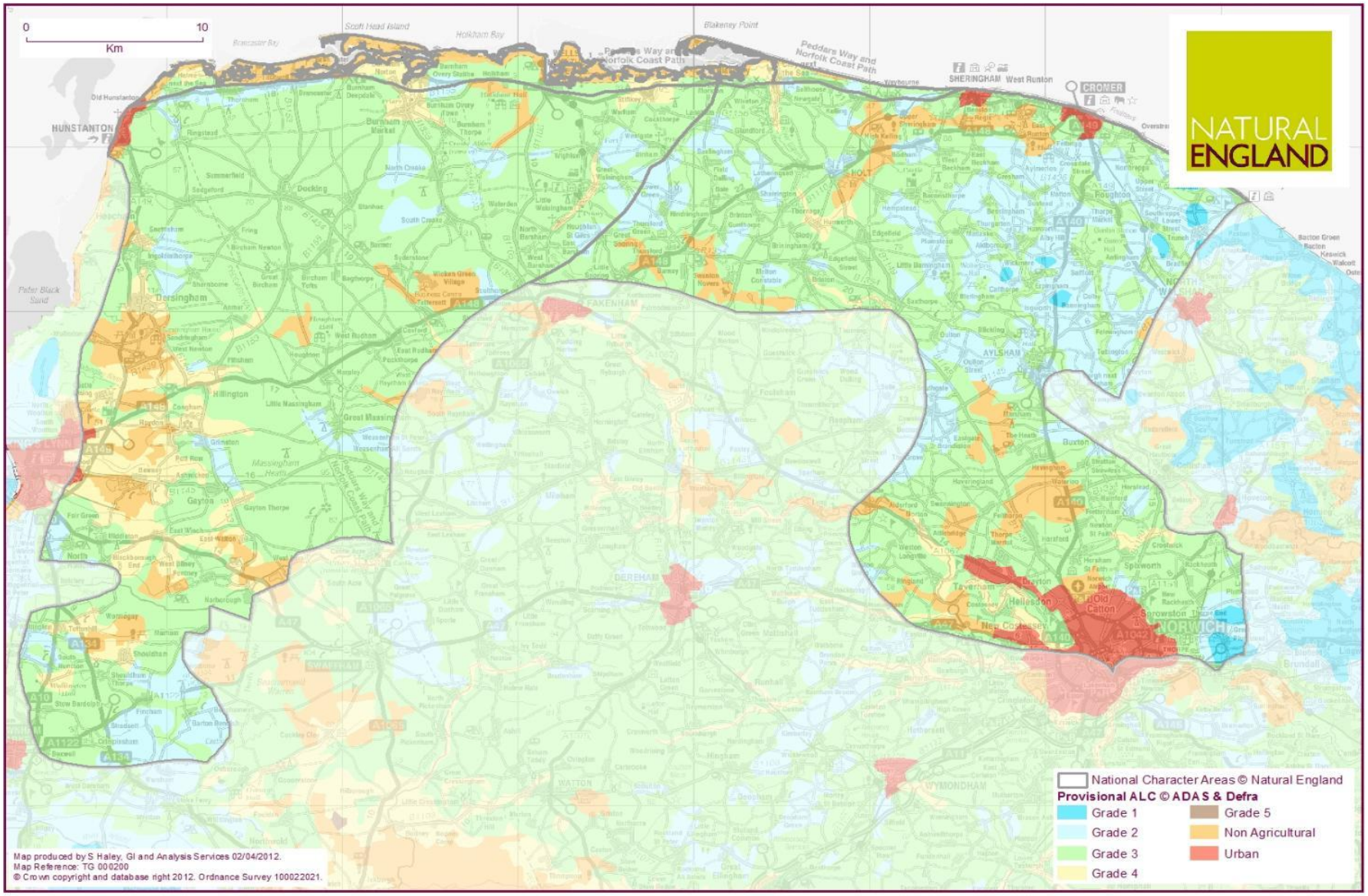


Figure N5: Agricultural Land Classification

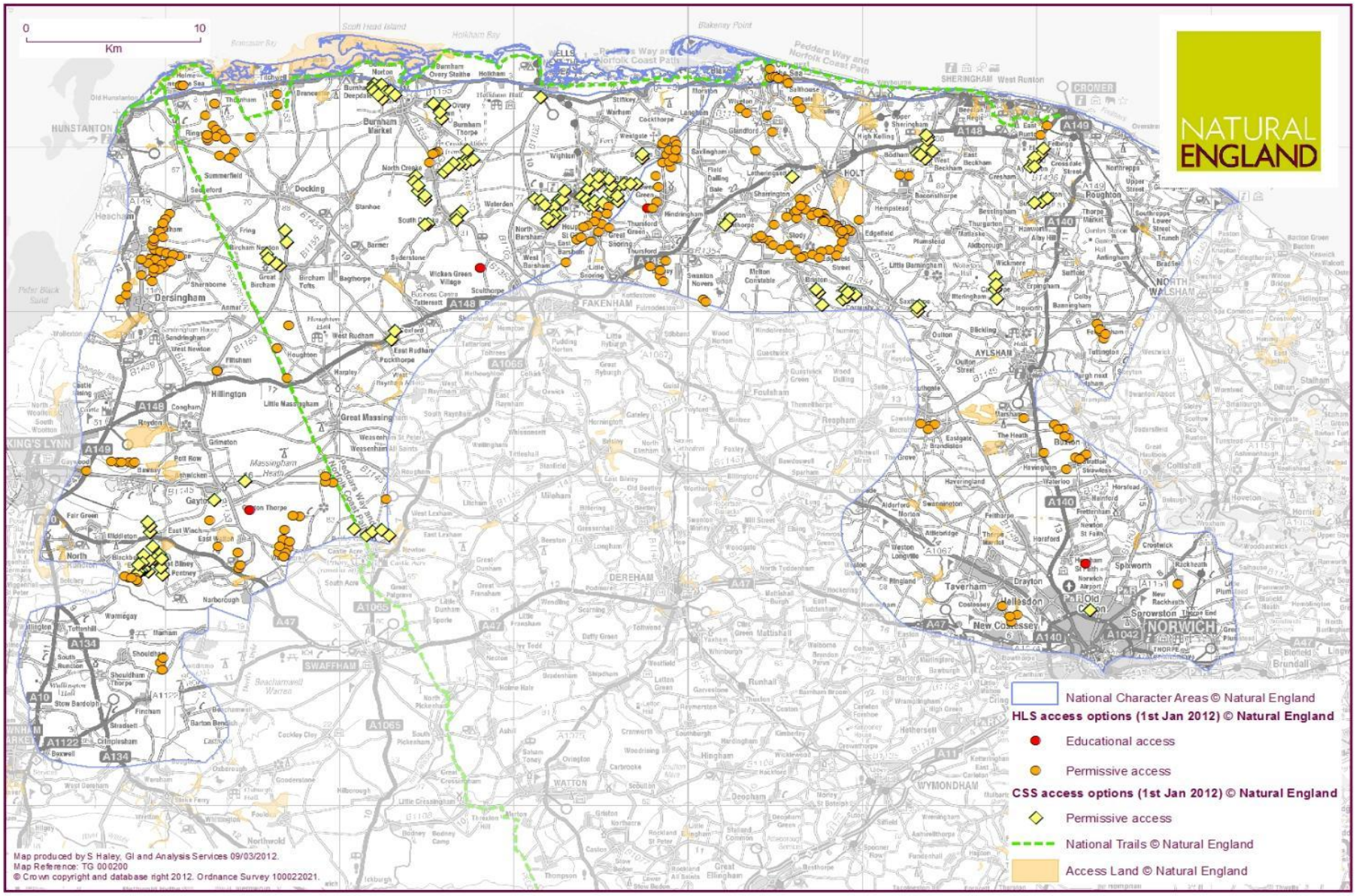


Figure N6: Access

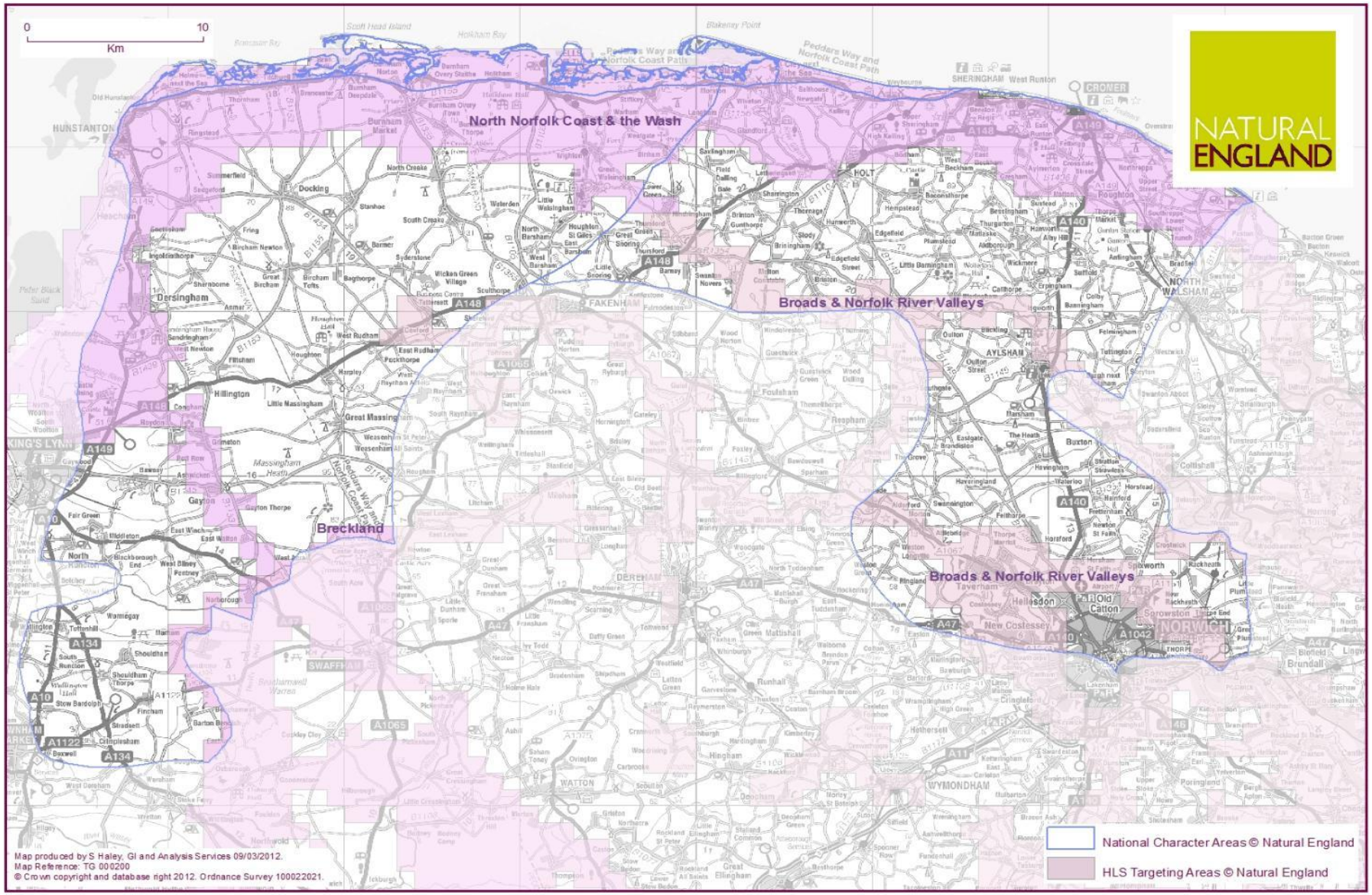


Figure N7: Higher Level Stewardship targeting

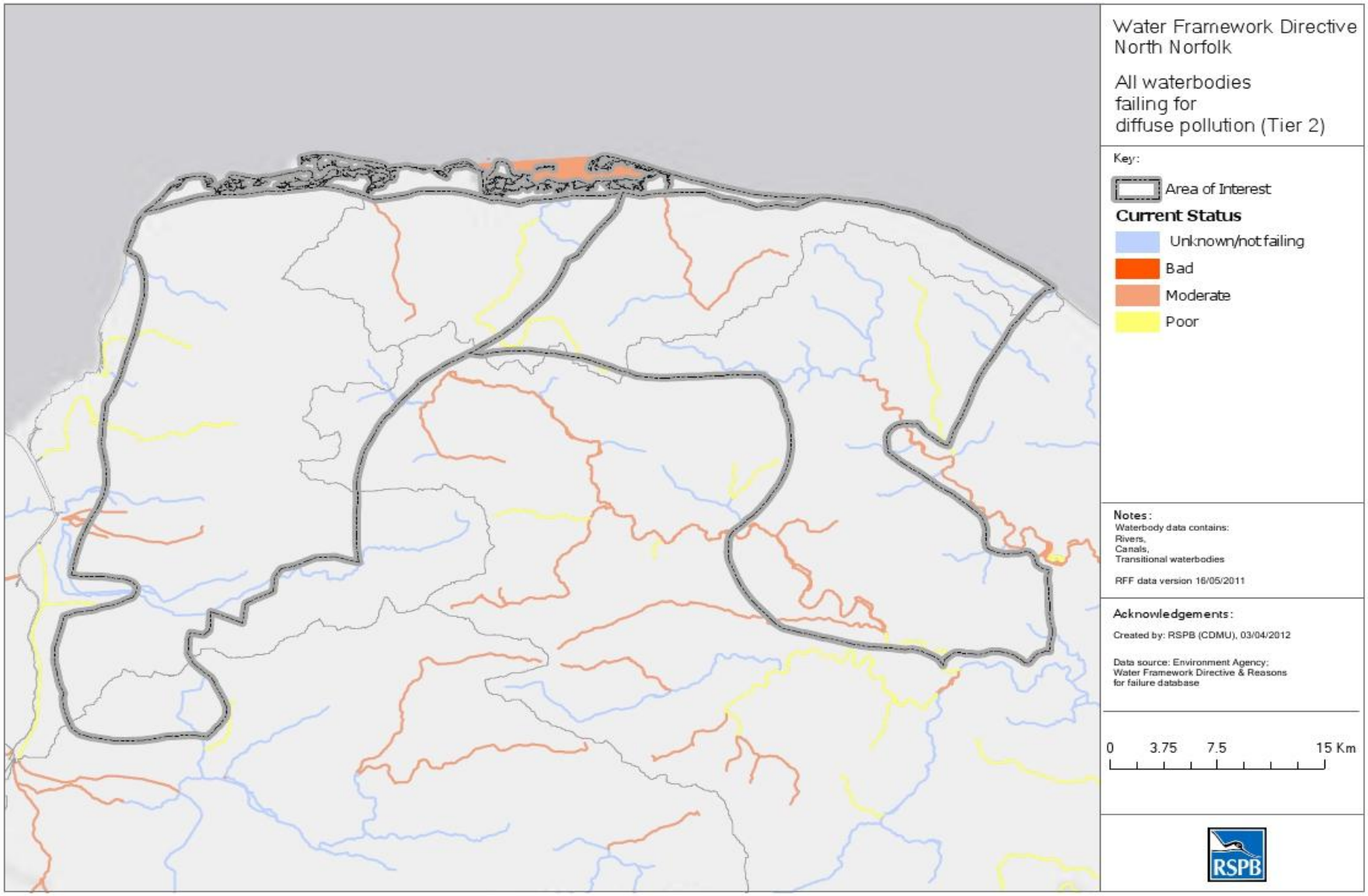
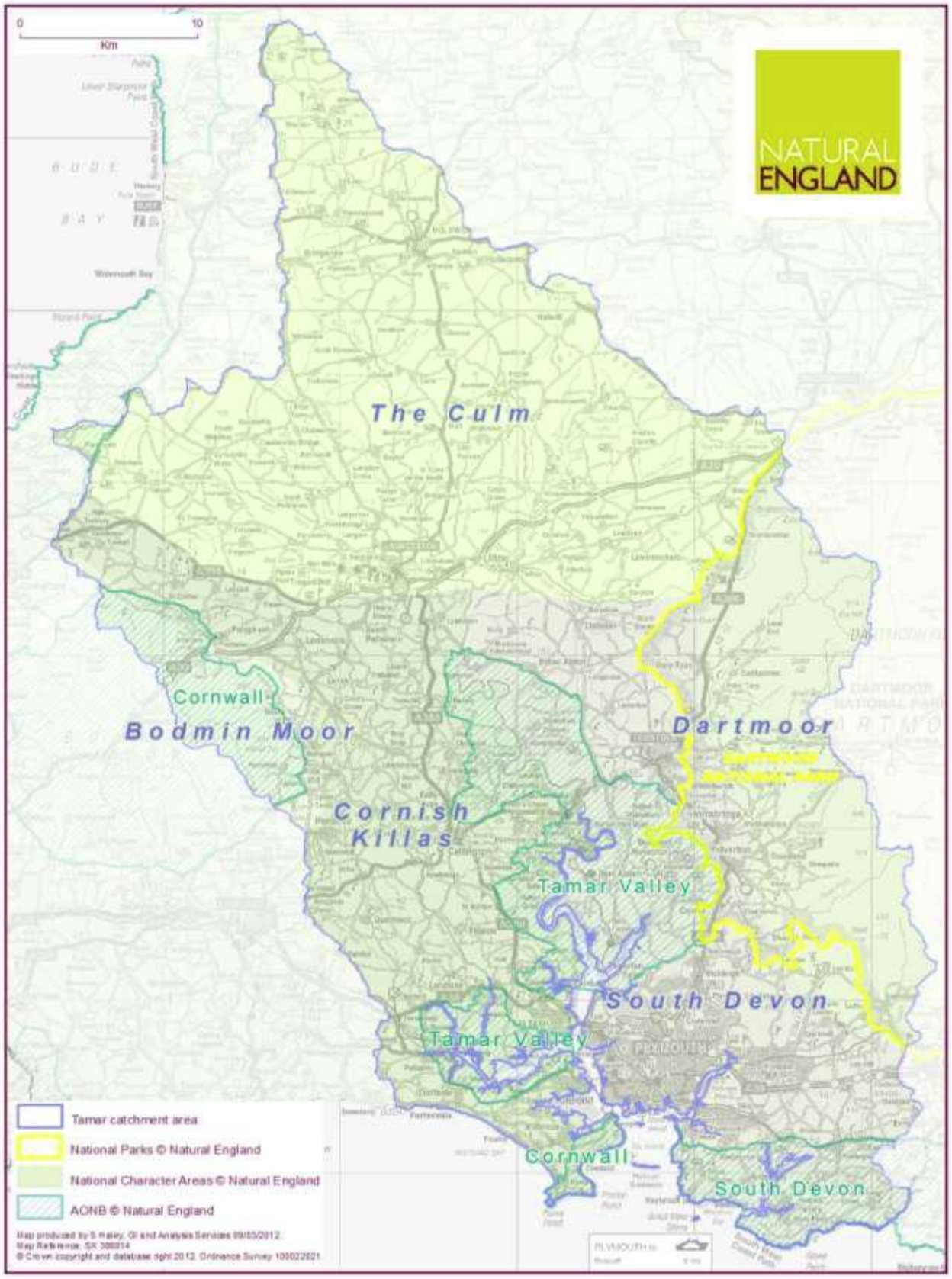


Figure N8: water bodies failing WFD on diffuse pollution



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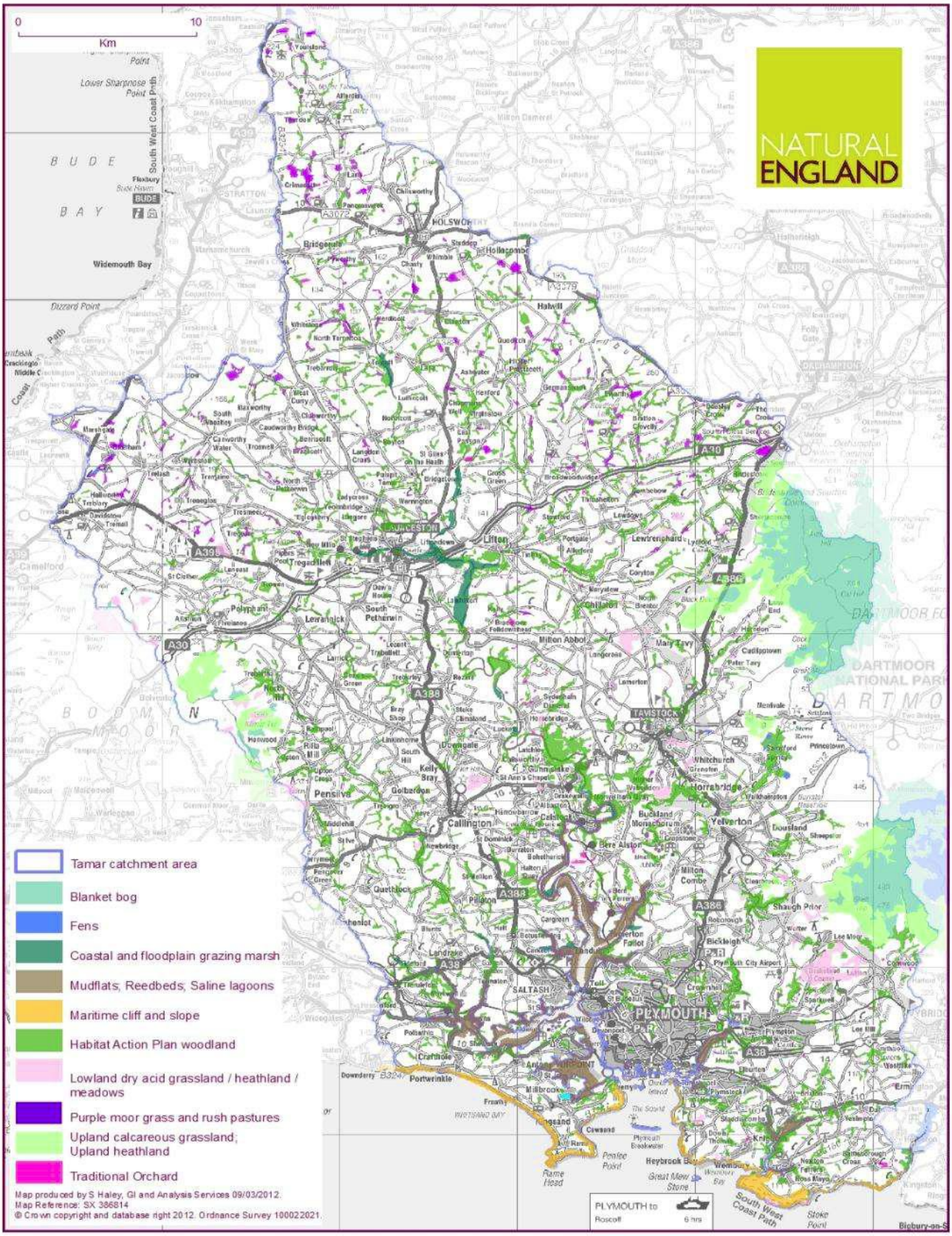


Figure T2: Biodiversity Action Plan habitats

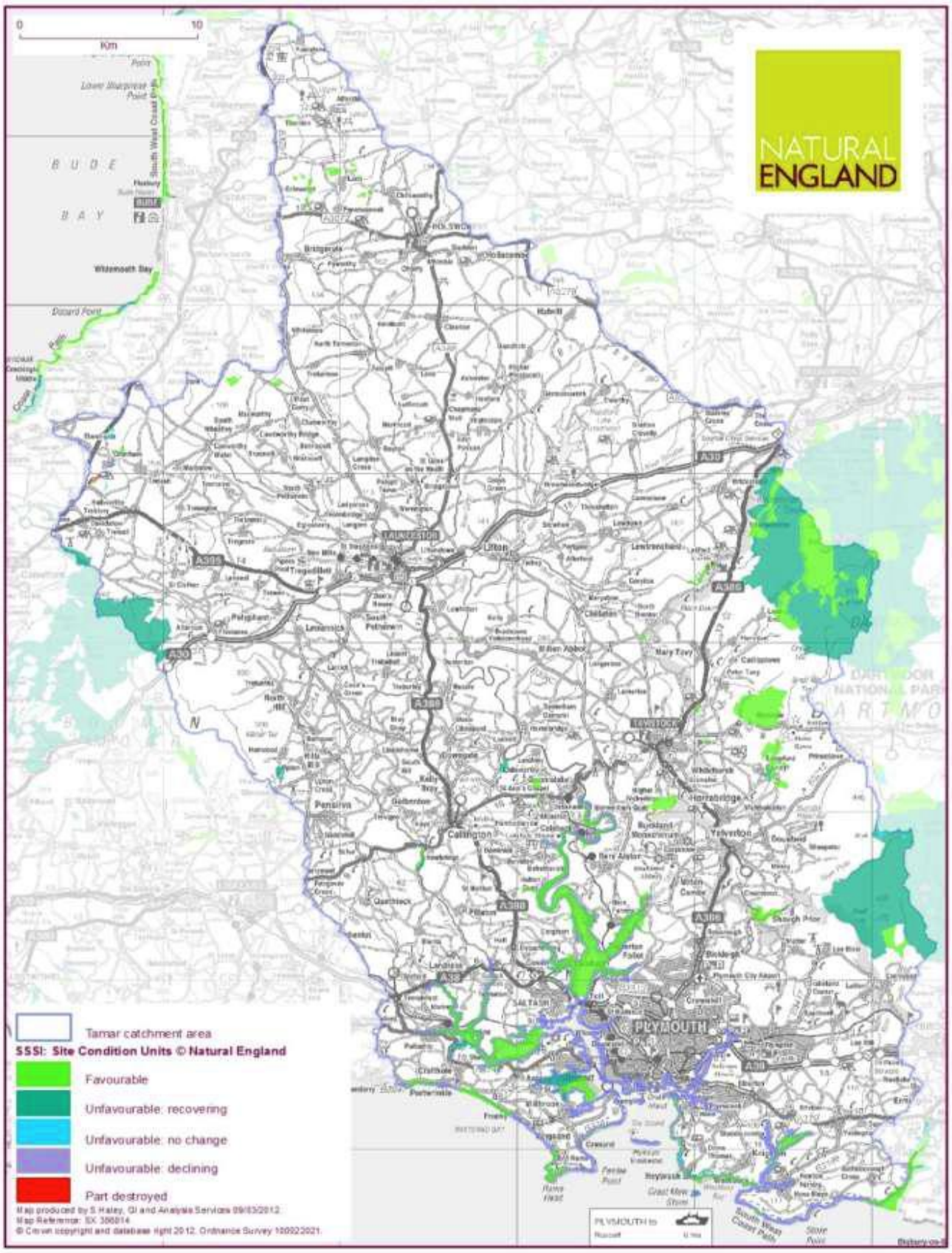


Figure T3: Location and condition of SSSIs

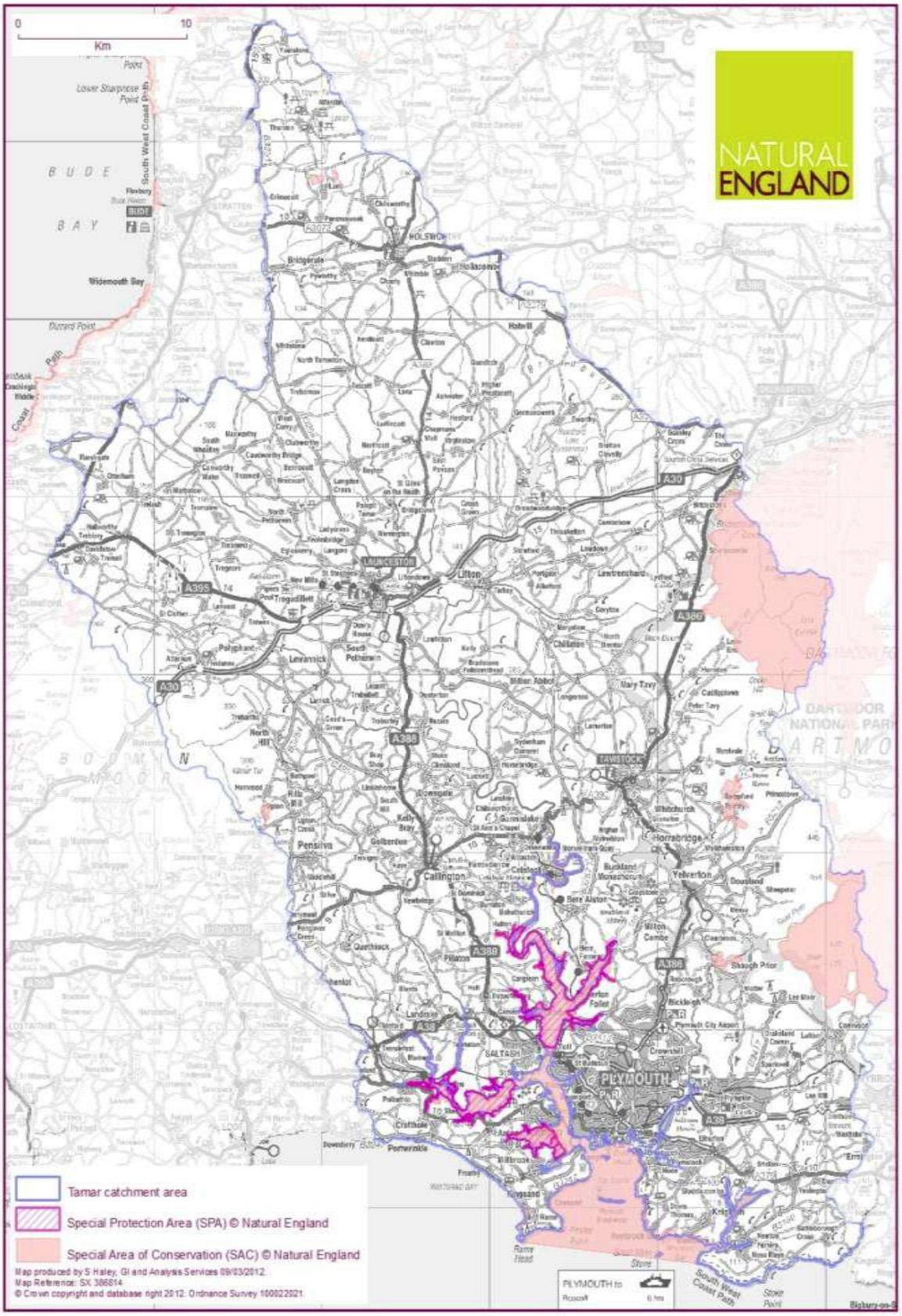


Figure T4: Statutory designations

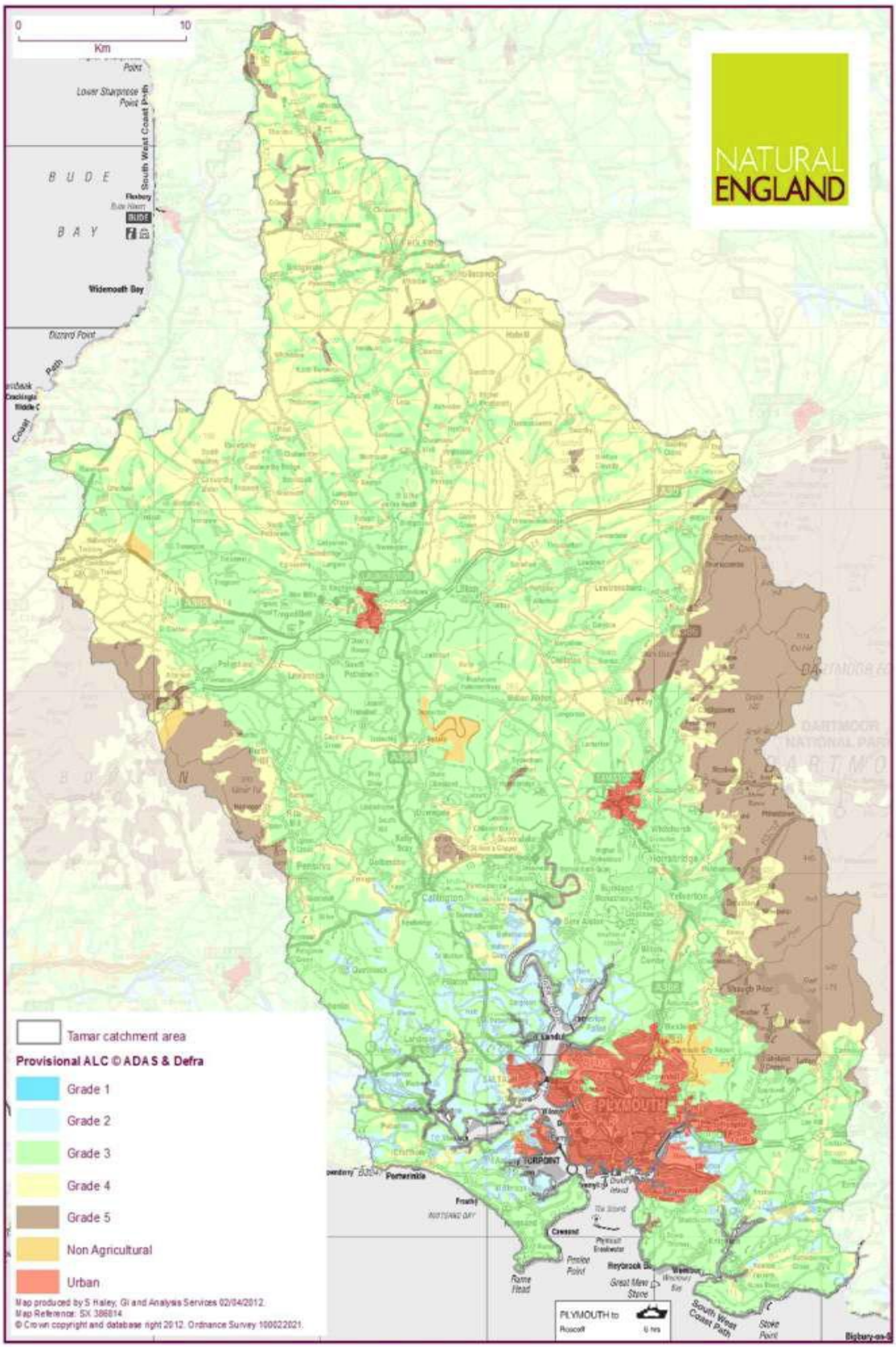
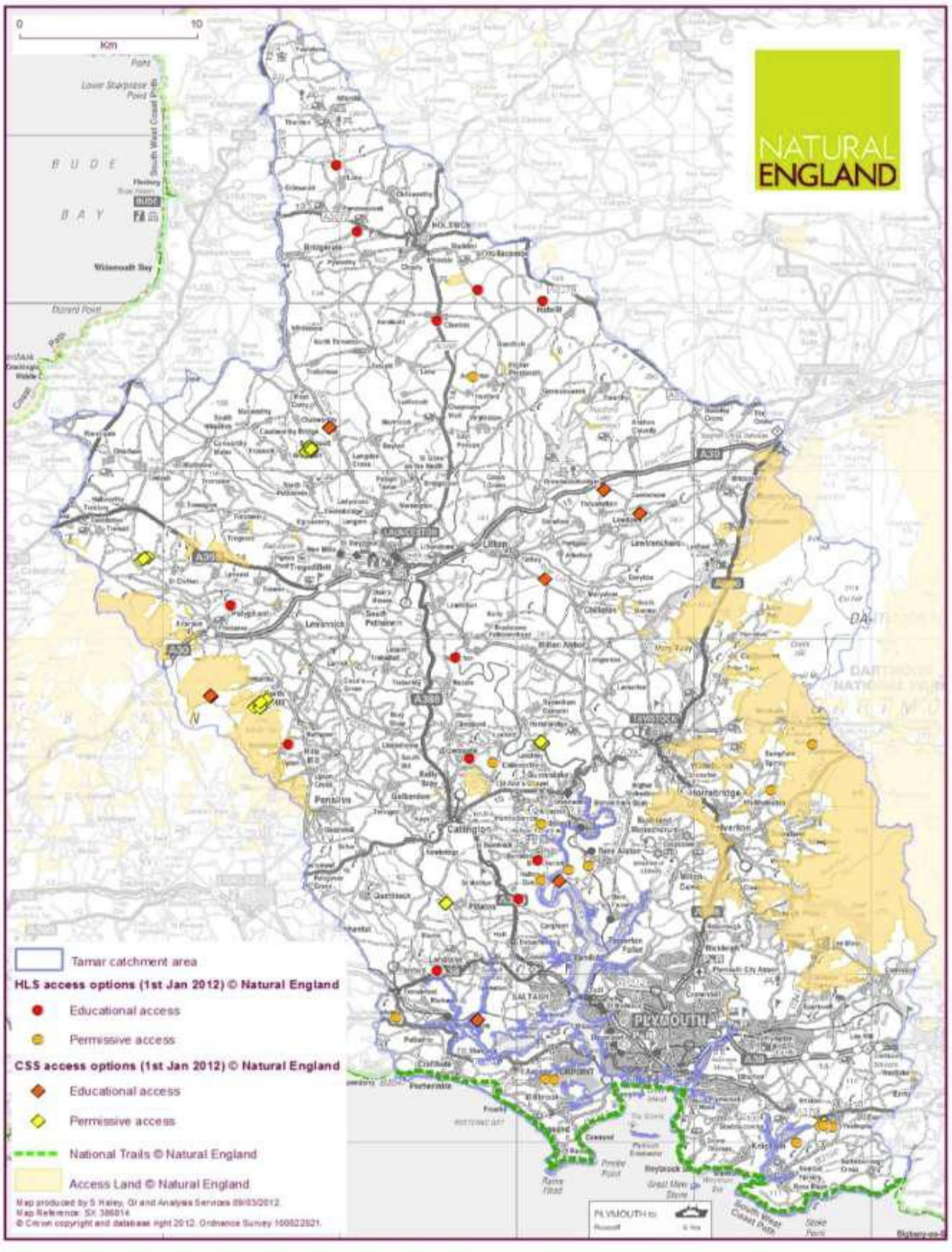


Figure T5: Agricultural Land Classification



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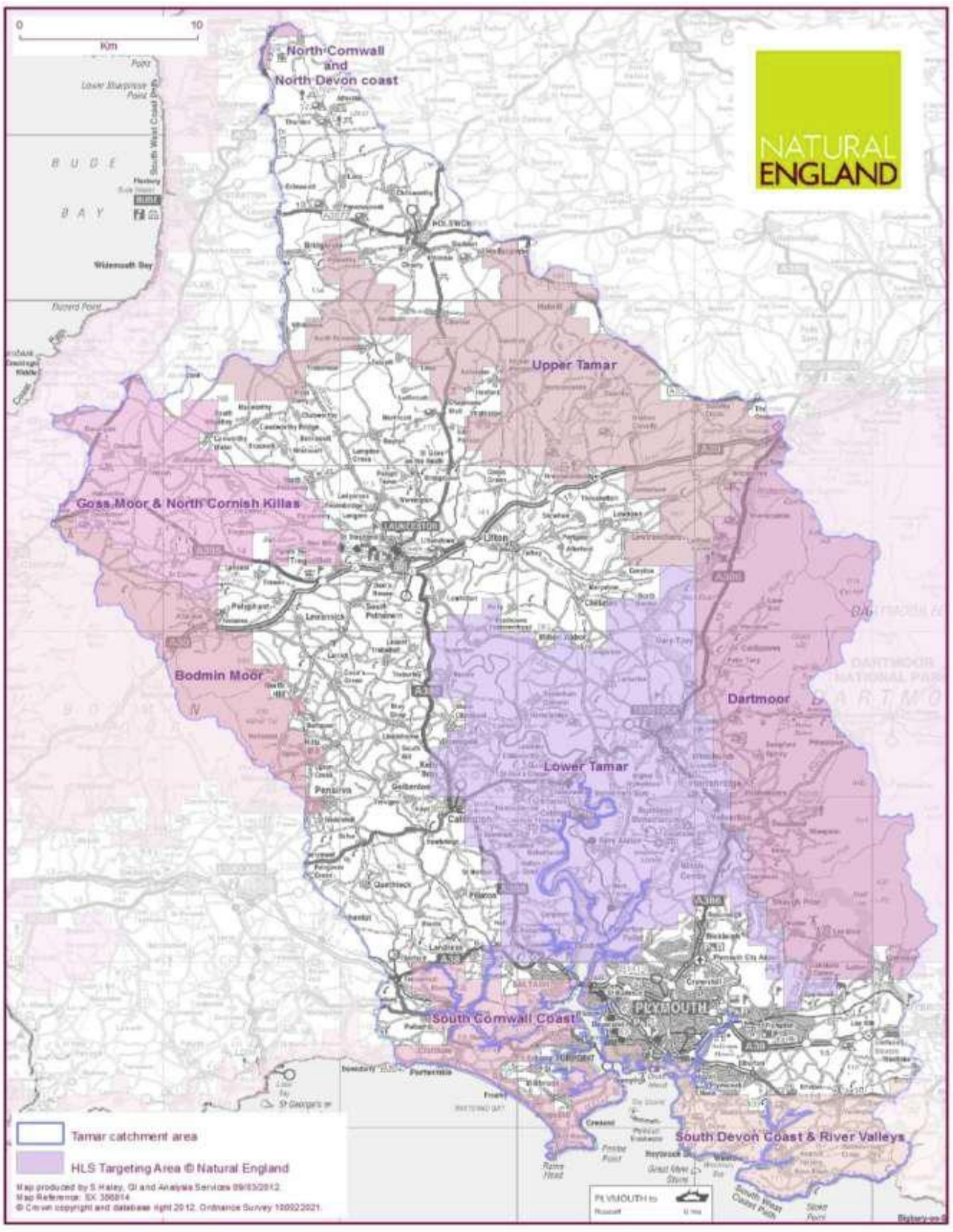


Figure T7: Higher Level Stewardship targeting

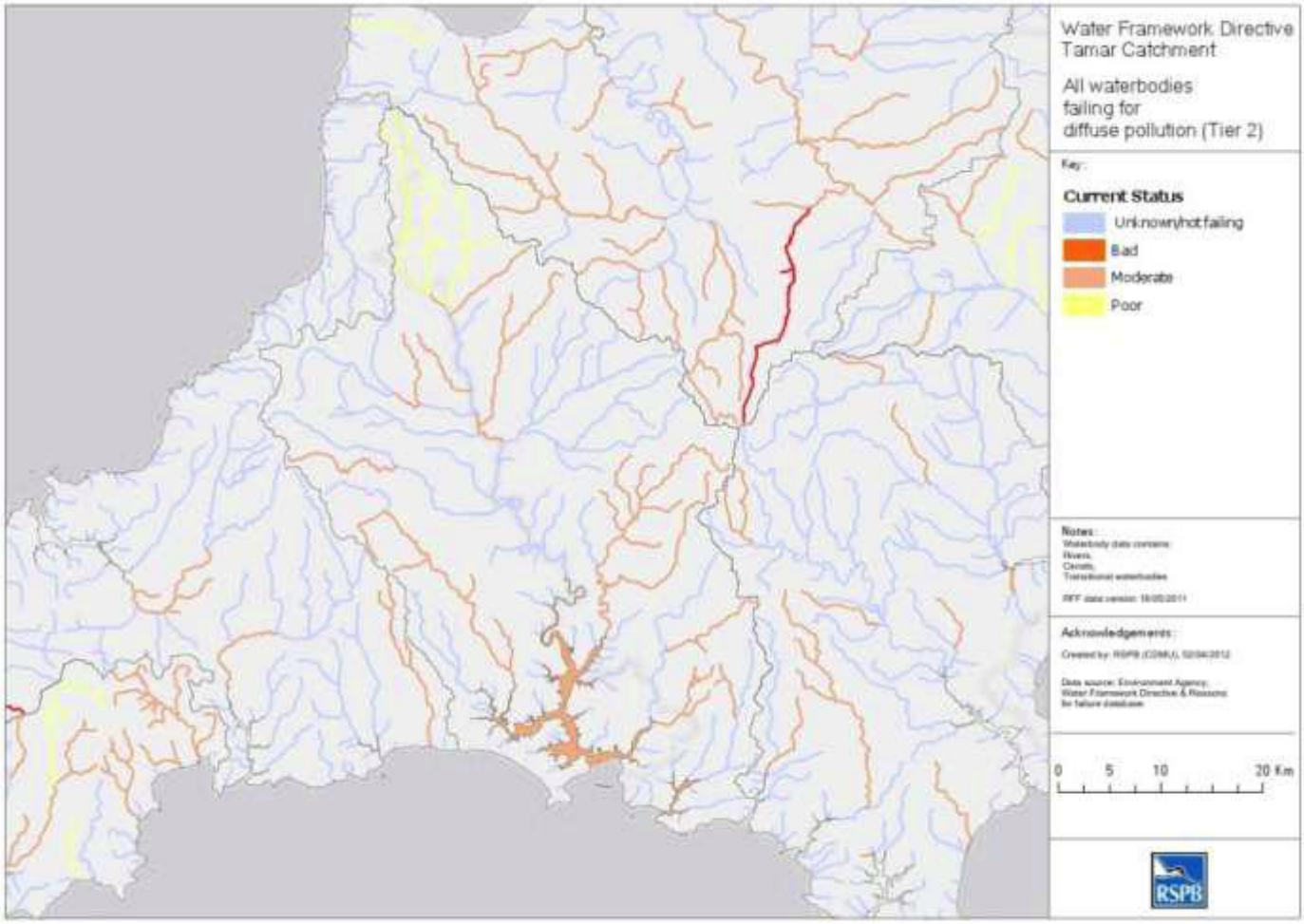


Figure T8: water bodies failing WFD on diffuse pollution

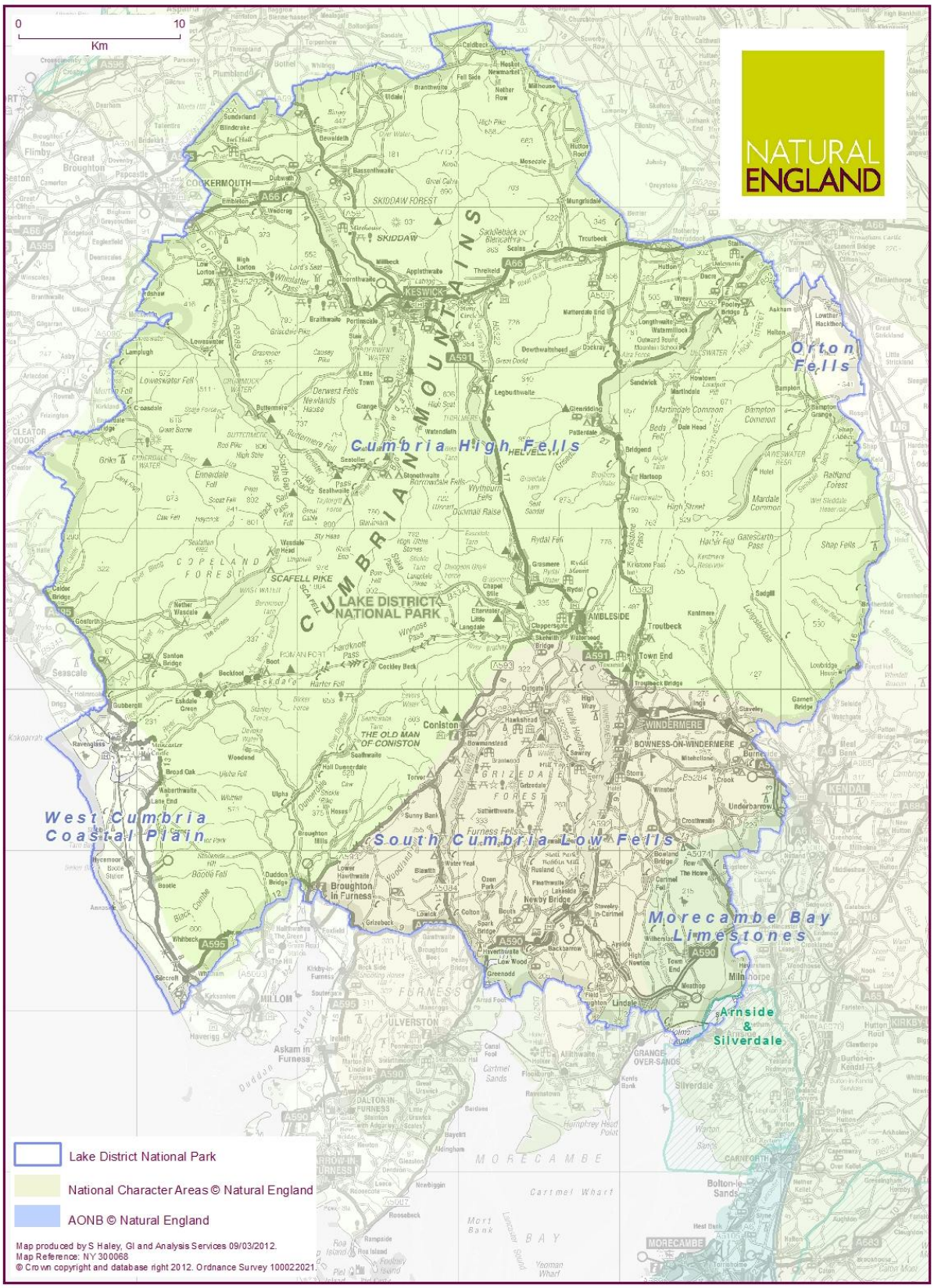


Figure L1: National Character Areas and landscape designation

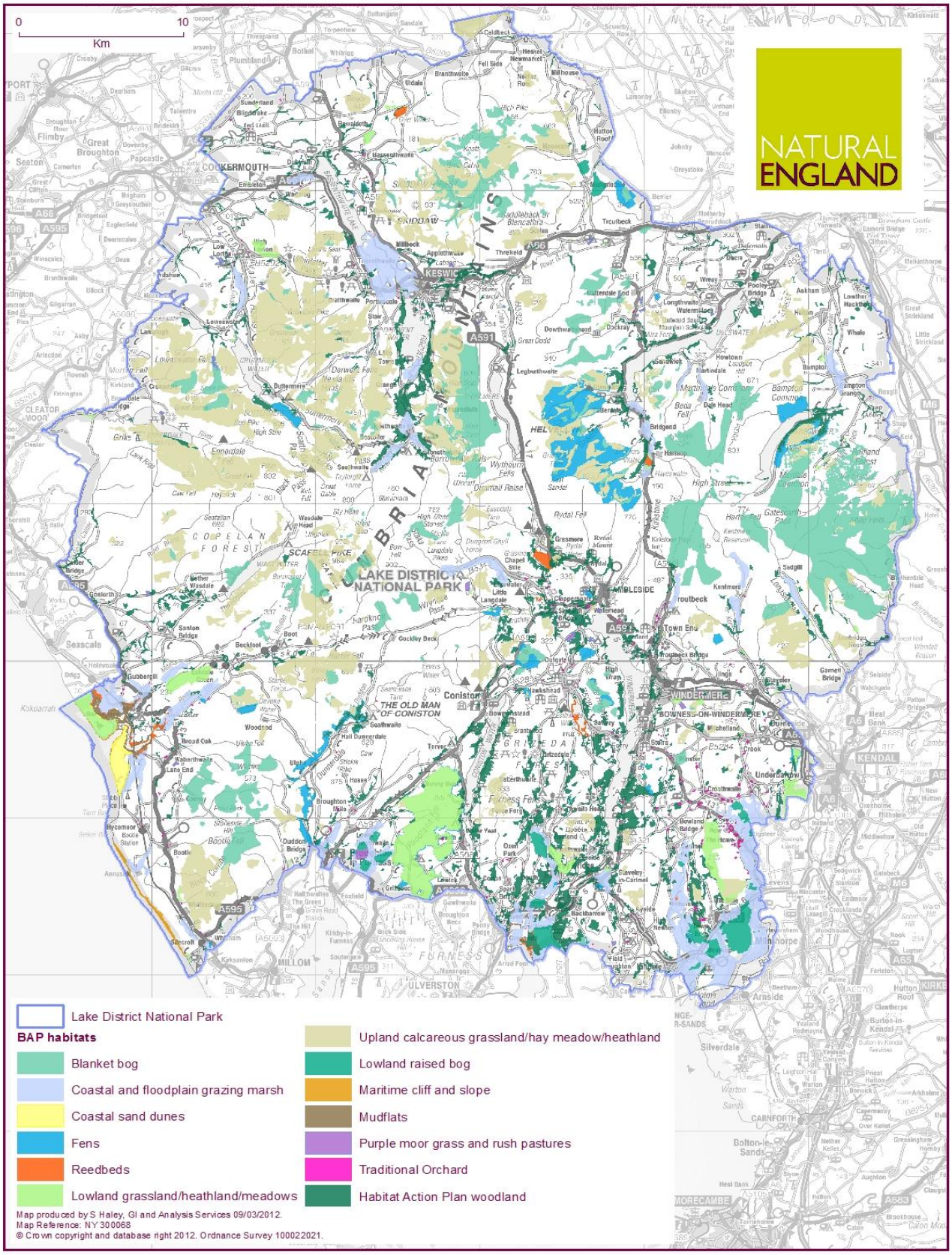


Figure L2: Biodiversity Action Plan habitats

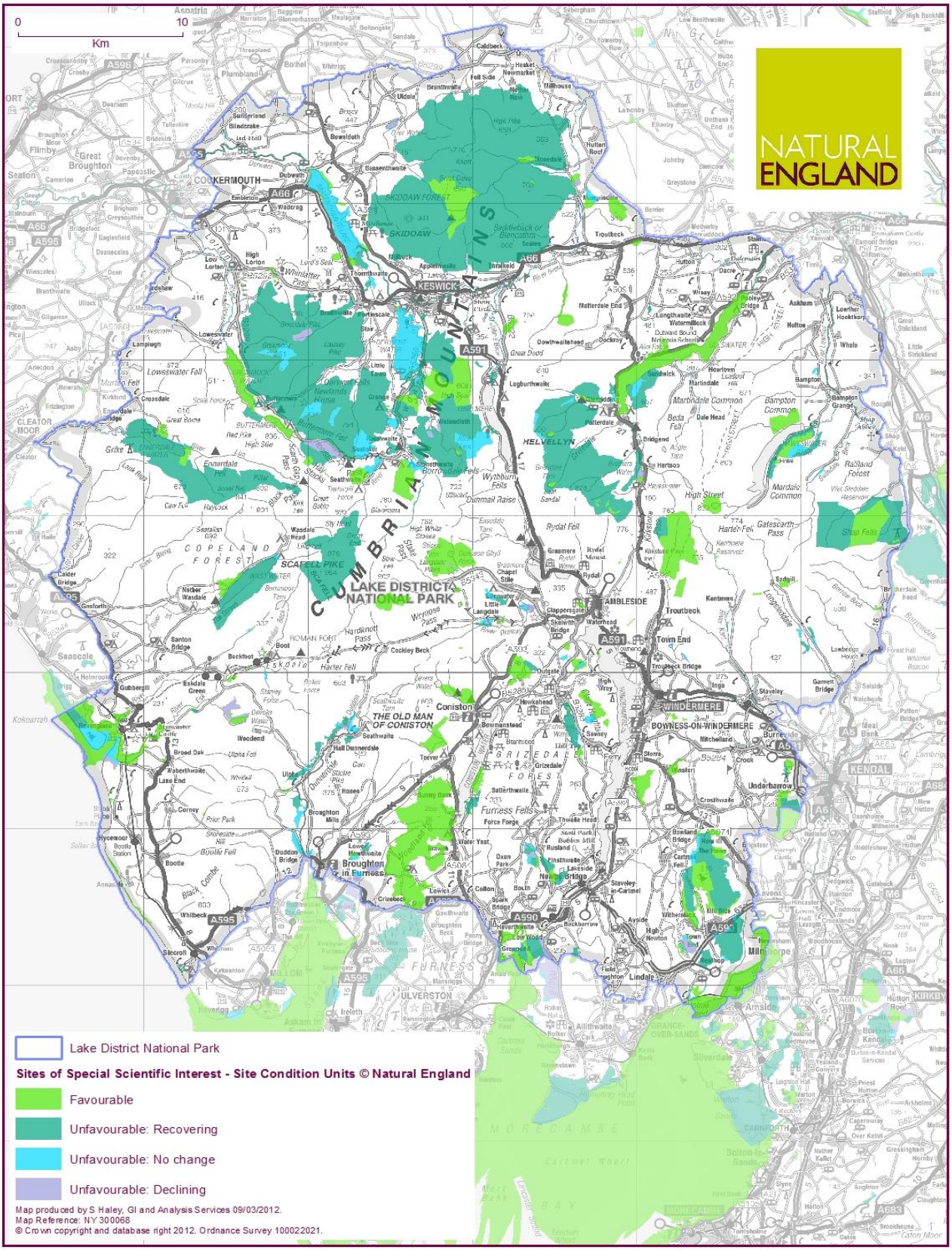


Figure L3: Location and condition of SSSIs

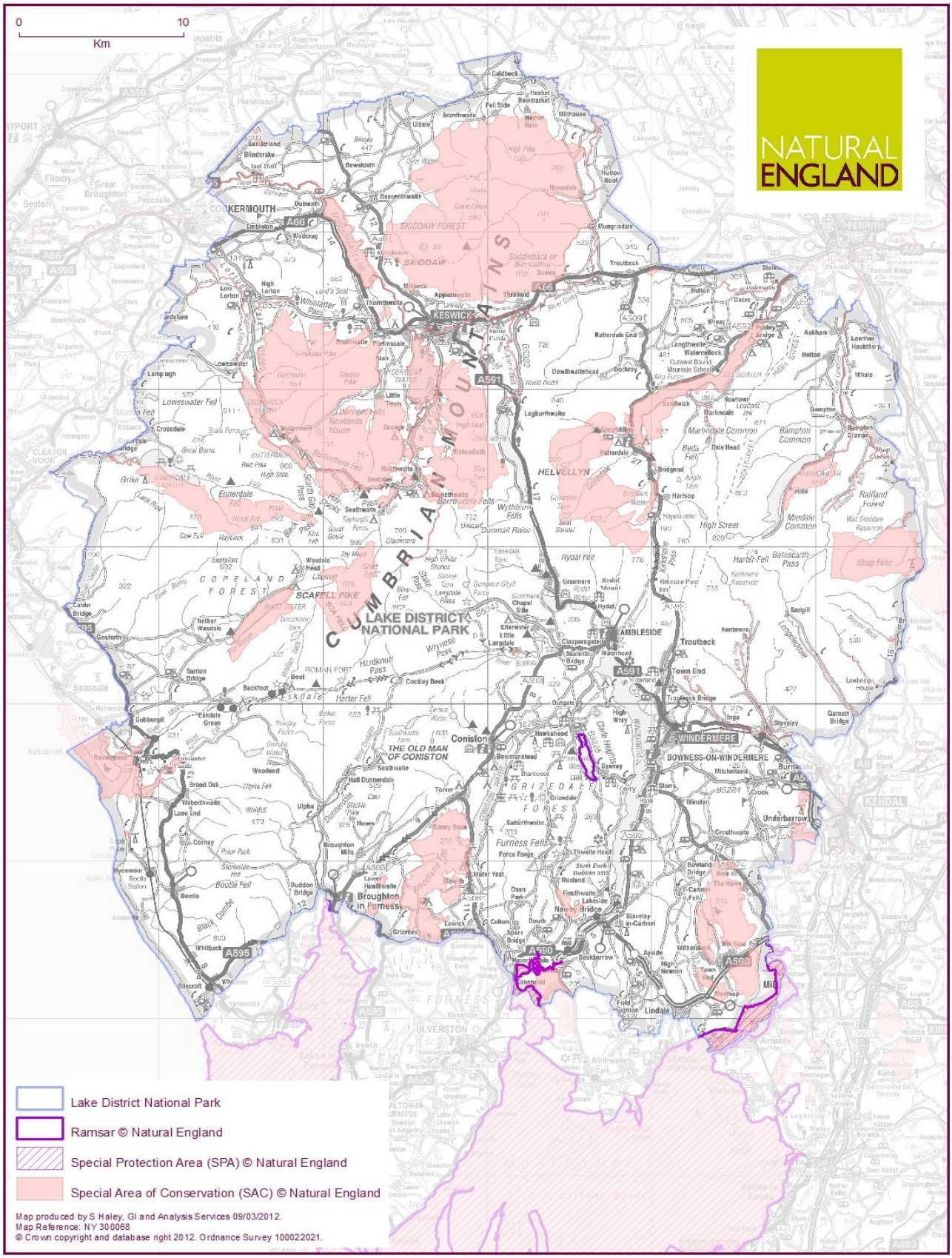
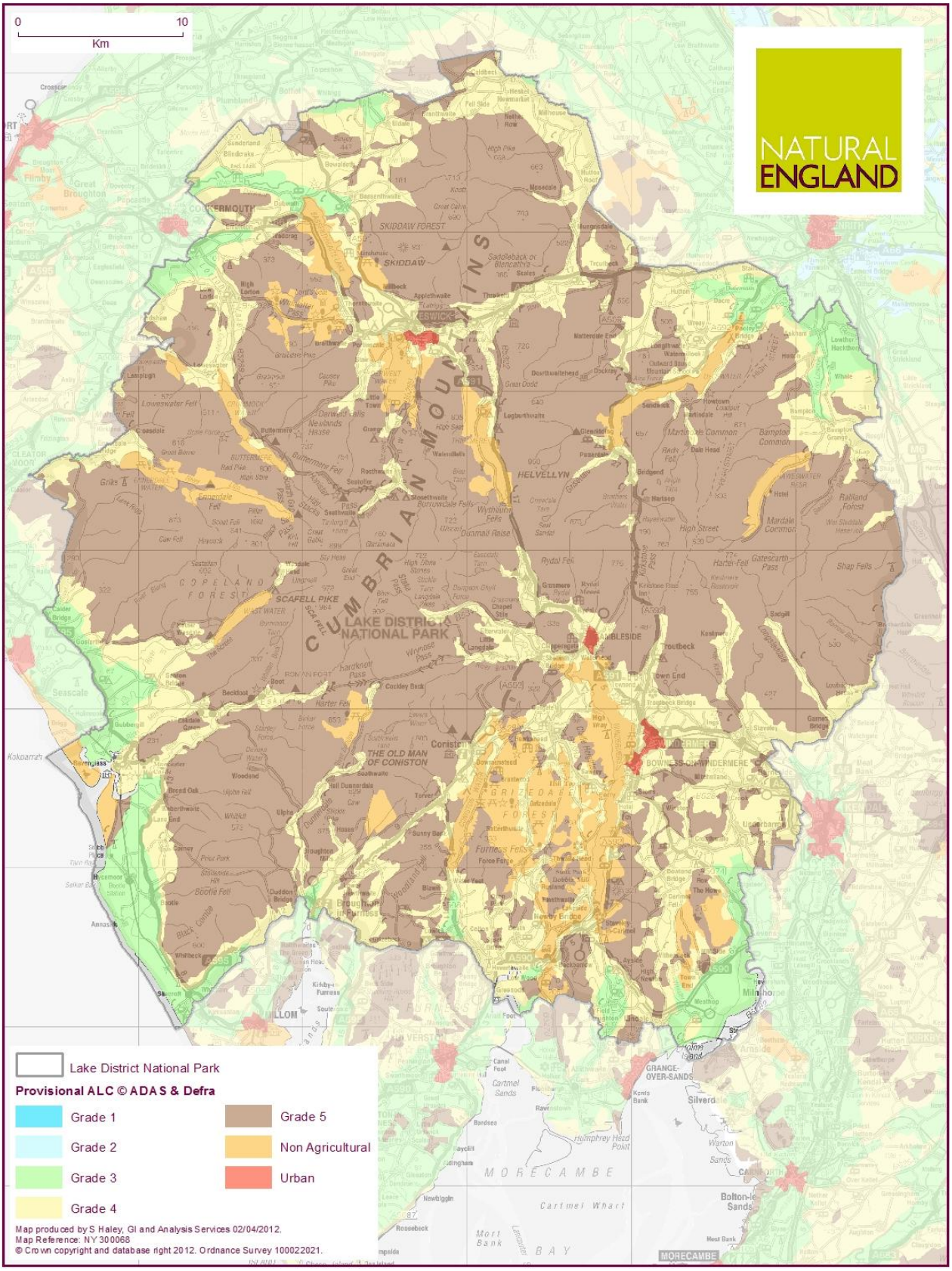


Figure L4: Statutory designations



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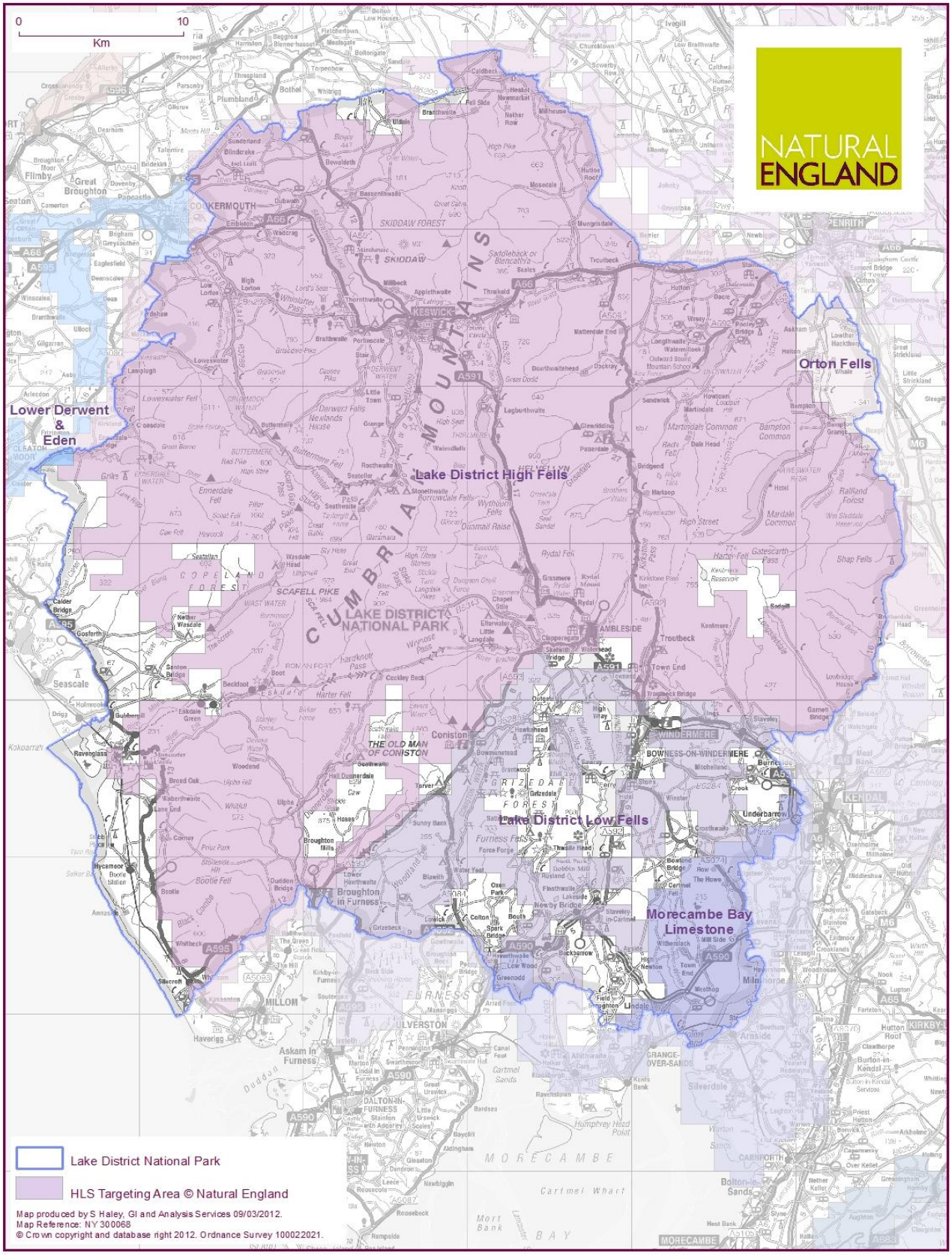
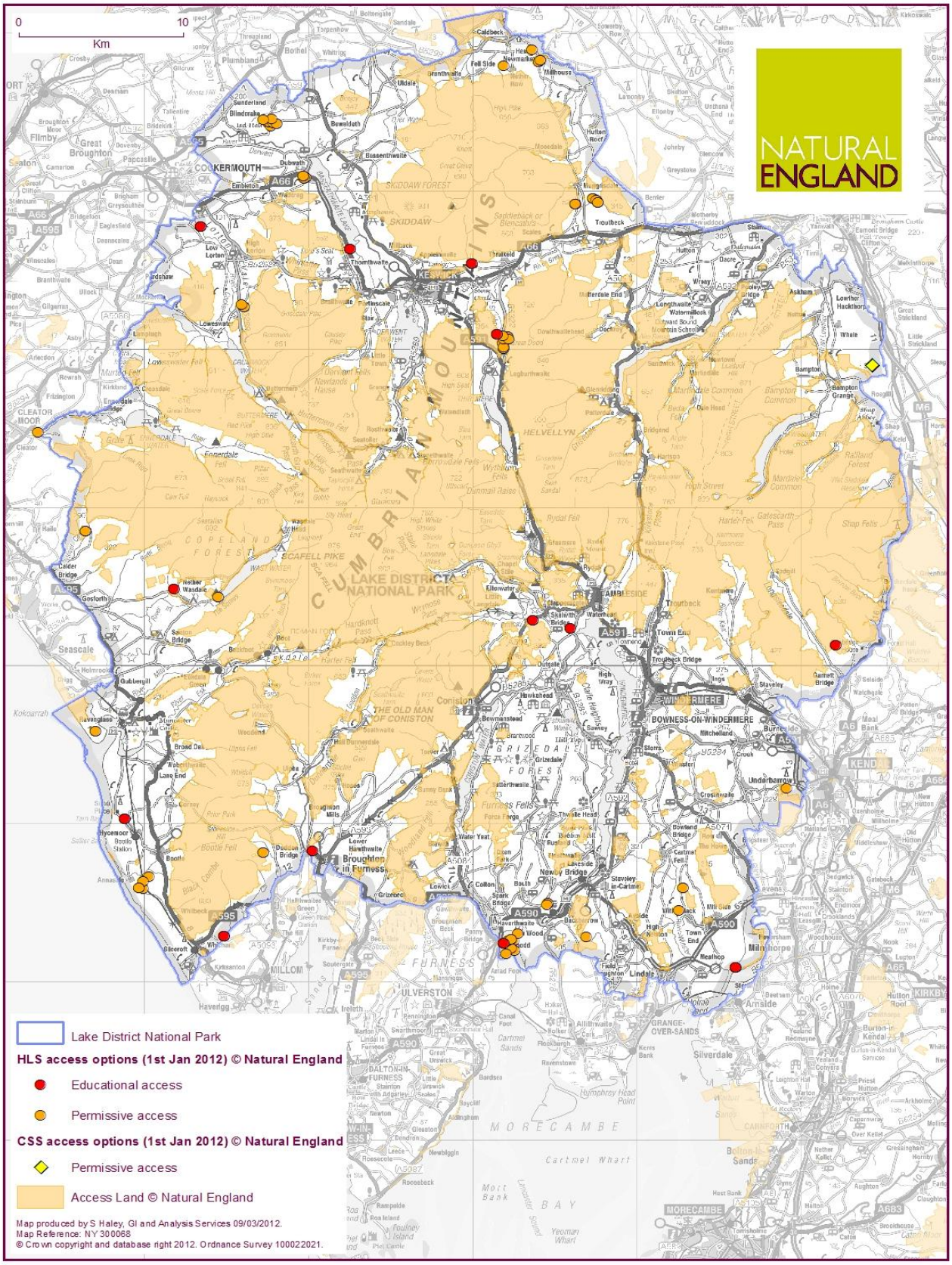


Figure L6: Higher Level Stewardship targeting



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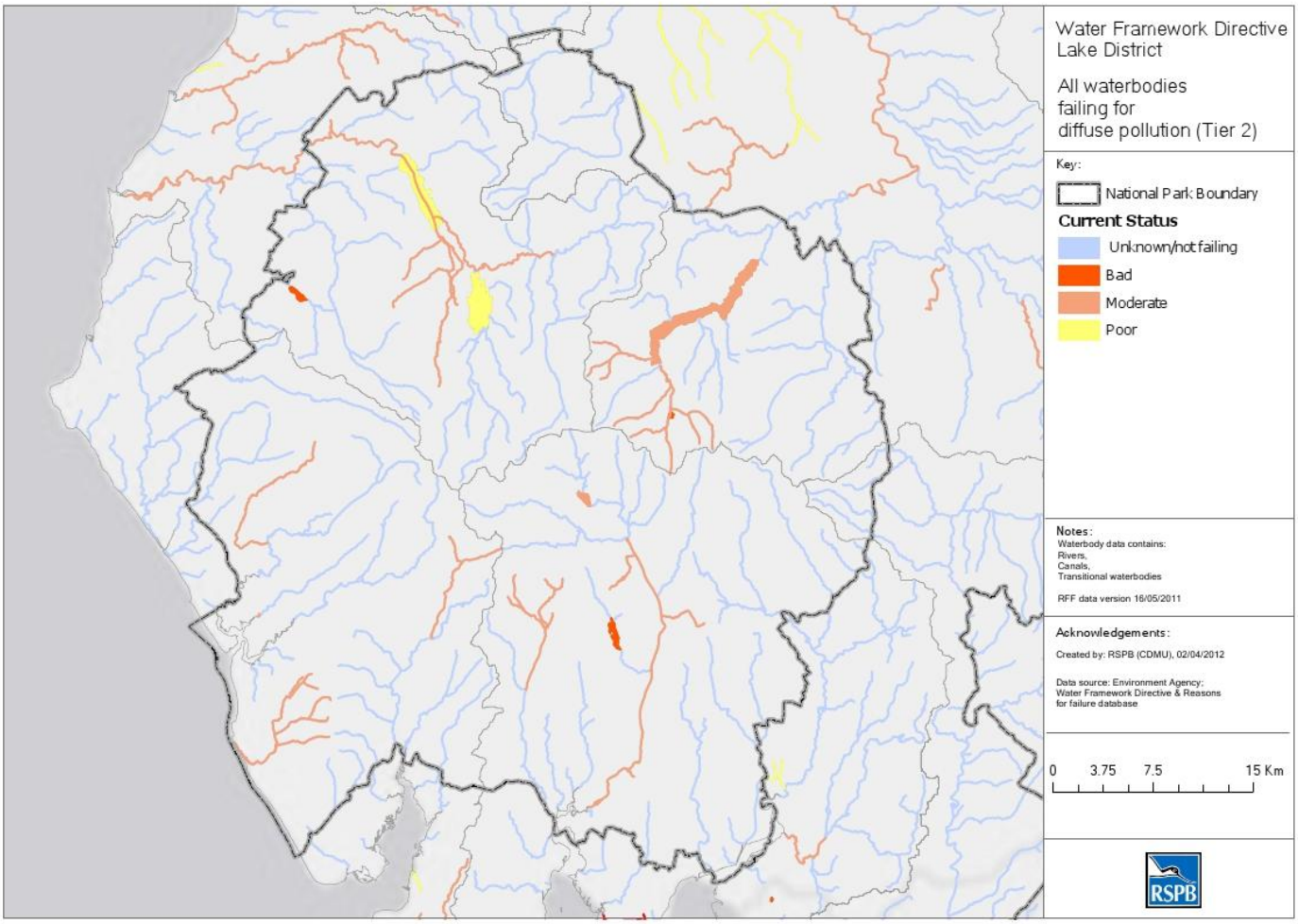

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